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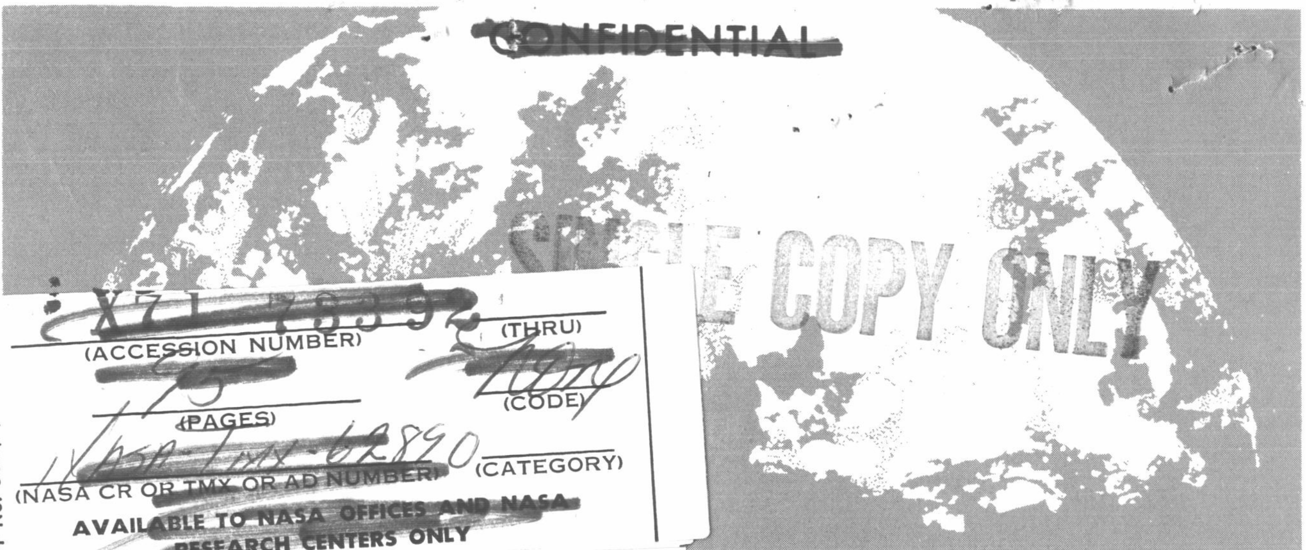

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROJECT APOLLO

QUARTERLY STATUS REPORT [U]

NO. 5

FOR PERIOD ENDING

SEPTEMBER 30, 1963

~~GROUP 4~~
~~Downgraded at 3-year intervals; declassified after 12 years~~

MANNED SPACECRAFT CENTER

NASA

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO SPACECRAFT PROJECT

QUARTERLY STATUS REPORT NO. 5

FOR

PERIOD ENDING SEPTEMBER 30, 1963

By Manned Spacecraft Center

FOREWORD

This report is the fifth in a series of reports on the status of the Apollo Spacecraft Project for the manned lunar landing program. The fourth status report described the development of spacecraft modules and systems through June 30, 1963; this report reflects activities and changes in status during the third calendar quarter, 1963.

SUMMARY

The Apollo space vehicle, consisting of the spacecraft and launch vehicle, is depicted in figure 1. The spacecraft is the responsibility of the Manned Spacecraft Center (MSC), Houston, Texas, while the launch vehicle is being developed by the George C. Marshall Space Flight Center (MSFC). The Apollo spacecraft configuration is shown in figure 2.

The Apollo spacecraft is composed of three separable modules: (1) the Command Module (CM) which houses the crew from the earth to the vicinity of the moon and return to the earth, (2) the Service Module (SM) which contains the propulsion system as well as other systems, and (3) the Lunar Excursion Module (LEM) which separates from the Command and Service Modules when in lunar orbit and descends to the lunar surface for manned exploration.

The basic launch vehicle for lunar missions is the Saturn V, which consists of three stages: the S-IC, S-II and S-IVB. The S-IC utilizes LOX-RP-1 propellants for five F-1 engines while the S-II stage uses LOX-LH_2 propellants for five J-2 engines. LOX-LH_2 propellants are used for the one J-2 engine in the S-IVB stage.

Major accomplishments of the Apollo Spacecraft Program during this reporting period were:

Command and Service Modules.- The Little Joe II qualification test vehicle (QTV) no. 1 was successfully launched from White Sands Missile Range, New Mexico, at 9:00 a.m. on August 28, 1963. The countdown proceeded with no holds encountered. The launch vehicle trajectory was within limits prescribed for a high Q abort flight (Mission A-001). All the systems performed satisfactorily, and all test objectives were successfully achieved with one exception. The destruct system used for thrust termination failed to detonate upon ground command. Examination of the wreckage and subsequent tests made at the range show the failure was due to primacord installation in the Safe and Arm Unit. Design changes are proposed to prevent failure on subsequent vehicles, however, repeat of the flight test will not be required. A photograph of the QTV liftoff is shown in figure 3.

The centrifuge fixture has been completed; all controls and displays are installed. The fixture has been tied to computing fixtures at Downey, California, configured to match those available at Aviation Medical Acceleration Laboratory (AMAL), Johnsville, Pa. The fixture is to be used for final functional checkout and familiarization of astronauts with the tasks to be performed on the centrifuge. AMAL personnel responsible for computer support installation and other details are participating in this checkout.

In support of Project Apollo, North American Aviation, Inc., the prime contractor, definitized the following major subcontracts during this reporting period:

Subcontractor	Design and Development of
AVCO Corporation	Heat protection system
Lockheed Propulsion Company	Launch escape system
Minneapolis-Honeywell Regulator Company	Stabilization and Control system
Link Division, General Precision, Inc.	Mission trainer

The fourth test with boilerplate 3 was successfully conducted on August 22, 1963. This test simulated nominal conditions after reentry and was the first test conducted after removal of the strakes.

The fifth test with boilerplate 3 was conducted September 6, 1963, and simulated the new boilerplate 6 configuration. Satisfactory recovery was not achieved due to damage of the main parachute harness assembly. The recommended changes to the parachute system and applicable structure resulting from this failure are being incorporated on boilerplates 6 and 19.

Lunar Excursion Module.- A formal review of the Grumman Aircraft Engineering Corporation M-1 Mockup was held at Grumman Aircraft Engineering Corporation on September 16, 17, and 18, 1963 by NASA personnel. The M-1 is a full scale representation of the LEM ascent stage crew compartment constructed primarily of wood and cardboard. It is complete in the representation of interior dimensions and accurately simulates the visibility available through the window. Significant results of the review were:

a. Crew Visibility: The window shape and visibility provided for the normal eye position are acceptable.

b. Panel Location and Placement: The general panel arrangement and space available appeared adequate. Location of specific displays/controls can be improved in accordance with new reach and vision envelopes resulting from the "stand-up" crew support and restraint concept.

c. Seating and Restraint: The concept of a standup position for both astronauts was approved. In general, it was felt that the restraint provisions in M-1 were unduly restrictive to crew mobility.

d. Location and Type of Hand Controller: The controllers were positioned too low and lacked suitable arm support required to achieve fine control.

e. Crew Station Arrangement: In general, the M-1 crew station arrangement is considered acceptable. However, the specific details of flight provisions require further MSC/Grumman Aircraft Engineering Corporation study.

Grumman Aircraft Engineering Corporation completed final negotiations with the Marquardt Corporation for reaction control subsystem development testing. Grumman Aircraft Engineering Corporation also completed contract negotiations with Pratt and Whitney Aircraft for the development and manufacture of fuel cells for the LEM electrical power supply.

MSC completed a study of the translational capabilities of the LEM during descent from hover. It revealed that better ranging was obtained through use of the main engine and vehicle attitude than through RCS translation. The optimum attitude angle for translation was approximately 20°.

Guidance and Control.- A contract was awarded to the Kollsman Instrument Company for the development of optical subsystems.

The make-or-buy plan for the LEM rendezvous and landing radars has been established.

Breadboard testing of the SCS flight control system has been completed.

The SCS was officially frozen, and design freeze on the bench maintenance equipment was completed.

MISSION PLAN

The objective of the Project Apollo lunar landing mission is for manned expeditions to carry out limited scientific observations on the lunar surface followed by a safe return of the crew to earth.

Another revision to the Apollo lunar landing mission plan was initiated during this quarter to function as the mission planning specification for the Apollo contractors. As such, more emphasis is being placed on ground rules, on the establishment of mission planning standards, and on mission related systems design requirements. This version will be published during the next quarter in loose leaf form. Loose leaf binders were selected so that additional details and revisions can be easily incorporated as they are approved.

There have been several meetings during this quarter to develop the MSC procedure for satisfying Atlantic Missile Range (AMR) range safety requirements, to estimate what those requirements might be and to better define the amount of support required from North American Aviation, Inc. The most pressing problem in need of resolution is the requirement for command destruct packages on the SM and LEM.

Two long range studies were initiated during this quarter. The first is the feasibility of using the LEM propulsion to serve as an alternate to the SPS. The other study is to evaluate all mission related ground rules in an attempt to determine how much each cost in terms of spacecraft weight.

Preliminary examination of the use of the LEM propulsion as a backup to the SPS has shown this capability to be very desirable during the early phases of the lunar landing missions, particularly for midcourse corrections during translunar flight. It also appears that this capability can be acquired with very little modification to the current design if control of the LEM propulsion engines is accomplished from the LEM. The detailed design of this capability, however, may result in a control dynamics problem; and the decision to go ahead with the capability is to be resolved during the next reporting period.

The main targets of the weight analysis on mission ground rules are those rules related to operational flexibility and growth potential. These studies are required in a timely manner because of the pressing spacecraft weight problems.

Launch Escape System

The launch escape system (LES) provides the means of propelling the CM to a safe altitude and position in the event of a pad abort or suborbital abort. Three rocket motors (launch escape, tower jettison, and pitch control) in addition to structural housings and a truss-type frame comprise the launch escape tower. The LES is shown in figure 7.

During this reporting period, five launch escape motors developed longitudinal cracks in the propellant grain valleys after being temperature cycled between 140° F and -20° F. The probable cause of failure has been identified as improper sealing of the motors during temperature cycling, which allowed considerable moisture condensation on the surface of the propellant grain. Excess moisture caused loss of propellant strength resulting in cracking at points of high stress. Tests to verify these conclusions and prove the adequacy of the fix will be completed shortly. The motor for boilerplate 6 pad abort vehicle was inspected twice, and the propellant grain was found to be in excellent condition with no evidence of being exposed to excessive moisture. Qualification testing is scheduled to begin during the next reporting period.

Development testing of the pitch control motor was successfully completed in July 1963. Qualification testing is scheduled to start in October 1963, to coincide with start of escape motor qualification tests.

Two motor firings remain in the tower jettison motor development program. These firings have been delayed to allow additional vibration tests and incorporation of a larger throat area. During vibration of one of the motors at 140° F, the propellant grain temperature increase was unusually high. Cause of the high temperature is unknown at this time. It was discovered that the test was not conducted according to the proper procedure. Therefore, additional tests are required to determine if a potential problem exists. The throat area has been increased slightly to lower the maximum chamber pressure in order to raise the safety factor from the design point of 1.4 to 1.5. The overall performance of the tower jettison system has not been adversely affected as the difference in thrust is only 2 to 3 percent. Qualification testing is scheduled to start during the next reporting period.

Structural static load tests on the tower have been successfully completed. A portion of the tower attach points tests will be repeated due to later modifications to the towers. These tests are scheduled for completion during the next reporting period.

Sequencer

The technique of escaping from the launch vehicle after the launch escape tower has been jettisoned is still under study. Results to date indicate that there are so many steps that must be taken in the proper order and with precise timing that the design goal of a fully manual sequence for an abort using the SPS may be impractical and a semi-automatic sequencer may be needed.

The mission sequencer interface with the launch vehicle emergency detection system (EDS) has been defined as a triple, hot-line connection across the spacecraft-launch vehicle plane of separation with a voting logic device in the sequencer. The triple-with-voting scheme assures that a single failure in the EDS will not disable the system and will not cause a false abort. The hot-line feature will assure an automatic abort if the structural connection fails. For certain ones the three interface connections are grouped together at the interface and then go down a common tube. The present plan for Saturn IB is to have four structural monitor hot-lines, 90° apart, all the way down the launch vehicle.

Command Module Structural System

The heat shield substructure will be changed from PH15-7MO stainless steel to PH14-8MO stainless steel subsequent to airframe (AFM) 001, 009, 002 and 006. Weight increases in the face sheets would be required for the cold soak condition due to the brittle behavior of PH15-7MO at cryogenic temperature. No fabrication problems are expected to result from this change.

Crew couch structural design was frozen during this reporting period and release of long lead time items started on August 30, 1963. A tabular structure has been adopted to eliminate the requirement to weld the titanium box members of the original design.

Delivery of the first dual mode explosive bolt prototypes is expected in December 1963.

The deisgn of the CSM separation system has been completed, and test hardware is being fabricated.

The extendible probe docking concept has been chosen as the primary approach for the docking system. A hardware test program, computer analysis, and flight simulation program have been initiated to evaluate the feasibility of several types of extendible probe/tether systems. Action is being taken by North American Aviation, Inc. and Grumman Aircraft Engineering Corporation to determine the stiffness requirement of the docking interface structure for compatibility with the stabilization and control system.

Service Module Structure System

AMR requirements for a destruct or fuel dispersal system are being explored. Requirements are expected to be finalized during the next quarter.

The effect of the fluctuating pressure environment during launch on the SM panel is being evaluated by North American Aviation, Inc., using a criteria formulated by MSC. Sled tests are under consideration as a means of testing for the environment.

Crew Equipment

The Gemini very high frequency (VHF) survival beacon is being reviewed for Apollo usage. A decision is expected in November 1963, after detailed review of beacon requirements.

MSC has concurred in North American Aviation, Inc.'s recommendation that MOCK-UP 12 be configured for use in lighting studies. North American Aviation, Inc. will present detailed plans for the lighting studies in November 1963.

The Apollo centrifuge program is on schedule. The fixture was shipped on September 30, 1963, to Johnsville, Pa., for installation (See Engineering Simulation Program CM/SM section of this report).

Arrangements have been made with the Air Force Systems Command for support of Apollo weightlessness tests. Both NASA and contractor activity provides for MSC approval of contractor test plans and Air Force approval of all safety of flight items.

Environmental Control System

The Environmental Control System (ECS) provides a shirt-sleeve environment in the crew compartment and is capable of providing this function for a three-man space flight for a two week period.

The regenerative heat exchanger which allowed the crew to adjust their suit inlet temperature was deleted. The suit inlet temperature will be maintained constant by the ECS, and flow control will be used to adjust crew comfort during suited conditions.

The required flow from the suit compressor during emergency decompressed conditions has been reduced from 12 cfm to 10 cfm per man (37 lb/hr total flow). The compressor output at the time of the requirement reduction was only 9-10 cfm per man at the 3.5 psia condition. Since a redesign of the compressor appeared necessary, the requirement was reviewed by MSC physiologists who determined that for such an emergency condition, 10 cfm per man would be adequate. North American Aviation, Inc./AiResearch then determined that this flow could be accommodated by incorporating a bypass in the LiOH cannister, thus reducing the total system pressure drop with an attendant flow increase. A minor modification of the compressor impeller was also investigated to provide the necessary flow, but test results showed no appreciable flow increase. North American Aviation, Inc./AiResearch are implementing the LiOH cannister bypass to increase suit flow rate in the emergency condition to the now required minimum of 37 lb/hr.

The freon tank for boost cooling was also deleted by North American Aviation, Inc. The glycol loop will be rearranged to allow use of the coolant in the glycol reservoir as a heat sink. North American Aviation, Inc. stated that MIT can accept a temperature transient of sufficient magnitude to allow the change. North American Aviation, Inc. is proceeding with implementation of the change, but further definition of the temperature transient and its acceptability to MIT will be obtained.

Glycol loop redundancy will be added for critical equipment to allow for a safe return from lunar orbit, following loss of the primary glycol loop. North American Aviation, Inc. has not implemented the change, pending better definition of which equipment is critical for such an abort condition. Most of the electronic equipment can be cycled in an emergency so as to preclude the need for redundant cold plates. Redundant crew cooling is provided by an existing water boiler. North American Aviation, Inc. will submit a complete plan of action for implementation of this change to MSC in October 1963.

The glycol evaporator is being redesigned to incorporate improved transient response control. The present approach to control is a simple water metering valve, but transient response was unacceptable.

The redesign recommended by AiResearch appears technically feasible but is complicated and heavy. North American Aviation, Inc. has been requested to obtain proposals from AiResearch for simplification of the originally recommended redesign.

North American Aviation, Inc. and MSC are studying possible problems concerned with moisture condensation in the CM interior. Consideration is being given to condensation on the walls and tubing as well as in the cabin heat exchanger.

The Perkin-Elmer Corporation has delivered the first prototype CO_2 sensor to MSC for evaluation. North American Aviation, Inc. is proceeding with procurement of this same unit as a part of the ECS flight instrumentation.

AiResearch development testing is now approximately 75 percent complete. Most components have completed at least one phase of development testing. Continued changes to optimize the system by decreasing weight and improving reliability have caused delays in completion of development.

AiResearch is running life tests on all the rotating equipment. Progress to date has been satisfactory in all respects. No premature failures have been encountered.

Start of the breadboard tests has been delayed because of late facility completion and lack of suitable test hardware. Delays to date are not critical due to slips in flight dates.

North American Aviation, Inc. is proceeding with man rating of the facility to accommodate the manned ECS test program. Food, waste management, and miscellaneous crew equipment will also be evaluated in these same tests on a non-interference basis. Sophisticated tests of the complete controls and displays were proposed by North American Aviation, Inc. but disapproved by MSC due to lack of a requirement for such tests and the possibility of unnecessary complication of the primary ECS test effort.

Guidance and Navigation System, Command Module

The guidance and navigation system provides semi-automatic control from translunar injection through the lunar mission and return to earth.

Three principal problem areas are reflected in the guidance and navigation schedules as of this reporting period:

a. The Apollo guidance computer redesign was first thought to cause a major schedule slip primarily due to necessary changes in the mechanical packaging and electronic specification control drawings (SCD). However, it now appears that a three month slip will occur; and due to the initiation of schedule recovery plan and producibility changes the delivery dates will be improved.

b. Late definition of interface coordination documents (ICD) by North American Aviation, Inc. and MIT/Instrumentation Laboratory has caused the electronic SCD's of the power servo assembly (PSA) and the PSA junction box to be late. This situation is only reflected in the PSA because of the complex, high density nature of these electronic components.

c. The LEM guidance and navigation hardware procurement plan is as yet unapproved by NASA Headquarters.

The design change, replacing the brazed nav base by a solid machined unit, was approved with effectivity of Apollo guidance equipment 7, and retrofit on Apollo guidance equipment 6 and 2. The MIT mechanical integrity model will use the brazed unit. MIT will provide valid extrapolation of test data to the new design.

Problem areas, which will be resolved during the next quarter are Display Keyboard (DSKY) Panel Electrotuminescent Light qualification and lack of program information in order to produce fixed memory core ropes.

<u>Inertial Measurement Unit (IMU) Stub Shaft Failure</u>.- All changes reflecting present resolutions have been released. A program involving the use of Belleville washers to damp relative IMU motion is under way. This damping effect will reduce the load magnification factor. A complete documentation package of the stub shaft problem including background, vibration history, analysis, test results, resolution, and improvement program has been assembled.

Design release for the coupling display units (CDU) was virtually completed. All that remains outstanding are a few assembly drawings.

The inertial reference integrating gyro (IRIG) for the reliability program technical negotiation was completed. Results were that the test schedule was moved forward about three months and the amount of test time was increased about 30 percent with no attendant cost increase.

The problem on the IRIG suspension capacitor module hermetic seal specification is nearing resolution. The original SCD contained no specification for the seal, and the delivered units failed to pass the silicone bath seal test but did pass the spray test joy bomb. However, it was decided to use the 90 components delivered in conjunction with tests intended to specify and check actual leak rate through the use of a dye in the plotting compound.

The IRIG delivery problem has improved. Based upon seven and one-half months lead time per system, as required per contract, and a minimum of five gyros per system to provide for spare and selectivity, a follow-on order will be required in the near future to avoid a delivery gap beginning in April 1964.

Computer test set breadboard 2 was completed.

System test for Apollo's guidance equipment 4 has slipped about one month due to completion delays of the PSA and the availability of the A.C. Spark Plug Division-General Motors Corporation pre-production GSE.

A.C. Spark Plug Division-General Motors Corporation was given authorization for the following:

a. To proceed with the design and fabrication of four signal load simulators for field site GSE

b. To proceed with the design and fabrication of GSE coolant system purging equipment

c. Under emergency clause to proceed with fabrication of 3 CDU's, IMU, and elements of the PSA to support the North American Aviation, Inc. simulation effort.

The optics, map and data viewer, IMU and coolant lines, bellows, nav base, and shock mounts for Apollo guidance equipment 5-A have been received by MIT. Shipping instructions for the display and controls, and the wiring harness have been provided.

One-half tray of the computer power supply has been integrated into the core rope tray. The core rope has been completely packaged on one-half tray instead of one full tray. The result is a reduction of approximately 0.41 ft^3 to a total of 1.15 ft^3.

Experience with Apollo guidance equipment 4 in system test at MIT has shown that inadvertently magnetization of the pulse integrating pendulum (PIP) is a problem. A.C. Spark Plug Division-General Motors Corporation has been directed to respond to an out-of-scope technical directive calling for the design and fabrication of a number of portable PIP demagnetizers.

A satisfactory schedule for delivery of GSE cold plates from North American Aviation, Inc. to MIT contractors was established and the first cold plates were delivered to MIT during this quarter. Delivery of thermal interface material for the cold plates is still indefinite, and North American Aviation, Inc. has been advised to establish a schedule for delivery of same to correspond with cold plate deliveries. Utlization of a MIT source of cold plates is being contemplated due to factors of North American Aviation, Inc. costs and schedule slips.

Due to the latest repackaging of the Apollo guidance computer (AGC) by MIT, investigation of impact on costs and schedules is being made. Considering the fact that this change reduces the size of the computer to allow the stowage of a complete spare computer within the assigned space allocated for one computer and spares, this change will greatly improve in-flight maintenance. This change lends itself to the utilization of double-redundant computer design which is currently being considered in lieu of the spare computer concept.

Venting of the S-IVB while in the earth parking orbit will cause initial condition uncertainties for translunar injection to be increased. The increase in uncertainty is due to the inability of the accelerometer to measure the velocity increment created during the vent since the impulse is in the order of the accelerometer bias. The resulting effect of this is to cause the first midcourse velocity corrections to be doubled. Studies at MIT/Instrumentation Laboratory indicate it is possible to measure the accelerometer bias while in earth orbit, and hence compensate for the bias. There may be operational problems associated with measurement of the accelerometer bias.

The use of gyro-compassing for pre-launch IMU alignment yields aximuth alignment accuracies sufficient to complete the mission with very littly ΔV penalty. This alignment accuracy is based upon a 5 meru stable gyro.

The shock and vibration qualification tests on the IMU shipping container were completed, and all results were positive.

Guidance and navigation system Apollo guidance equipment 5-A was shipped to North American Aviation, Inc. personnel witnessing disassembly and assembly of the system at MIT before shipment.

Stabilization and Control System, Command Module

A failure mode analysis of the SCS for entry and thrust vector control (TVC) has been completed and released by North American Aviation, Inc.

SCS control equations have been defined from the analytic block diagrams.

The preliminary failure effects analysis of the SCS for mission of AFRM 011 has been completed.

The SCS system design was officially frozen. Design freeze on the bench maintenance equipment was completed. All future changes to the system will be controlled by an interim configuration control procedure to be administered by North American Aviation, Inc. Formal change control board procedures will be instituted on delivery of the first SCS system.

Casting drawings for the sensor block and base of the rate gyro package were released to production. All piece parts drawings for the chassis, including brazing assemblies, have been released. First subassembly drawings for the translational controller and main body costing drawings were completed.

The TVC amplifier studies have been completed. The bench maintenance equipment rate gyro test console was satisfactorily checked out and accepted by North American Aviation, Inc. and USAF inspectors. MSC has received the SCS total system schematic representing the SCS design as frozen.

Procurement of rotational and translational controllers and flight director attitude indicator (FDAI) from Minneapolis-Honeywell Regulator Co. has been started to support the forthcoming Johnsville centrifuge program.

Reaction Control Systems

The function of the RCS is to provide attitude control for the spacecraft.

As of this reporting period, 28 CM RCS engines have been tested. Of the 28 engines, 21 were of a "workhorse" configuration and 7 were flight weight prototypes. Since the last status report, the following mechanical and performance difficulties have been encountered and remedial measures have been taken.

a. Injector pressure drop was found to exceed the design pressure budget. Enlargement of both oxidizer and fuel orifices has resolved this problem with less than one percent performance degradation.

b. Random cracking occurred in the macerated outer chamber ablative billet. Analysis of this material, subsequent to test, indicated that macerated fiber length was essentially "zero" and actual strength was significantly less than design values. Chamber construction has been redesigned throughout to incorporate oriented ablative material in lieu of the macerated material. Engines incorporating this new design are scheduled for test during the next reporting period.

No improvement in the throat cracking previously observed in the C/M RCS engine has been obtained since June 1963. Alternate throat insert designs to have been tested to support design change decision on August 17, 1963, have not yet been tested and will not be tested by Rocketdyne until January 1964. Testing of the alternate designs has been de-emphasized by Rocketdyne without justification. Cracking is still evident in both the Silicon carbide and Tungsten capsulation materials and still exhibits random orientation.

Prototype testing of the SM RCS engine with the 12" on 12" doublet impingement injector was terminated prior to completion of the planned program. Termination was necessitated by the occurrence of thrust chamber fragmentation and burn-through failures. Investigations are underway to determine the causes for these failures and the design modifications necessary to prevent future occurrences.

A weldment porosity problem was encountered at Airite during fabrication of the CSM RCS titanium propellant tank shells for Bell Aerosystems Company. Porosity has been reduced to acceptable limits by incorporation of more stringent fabrication and cleaning controls. Successful weldments are now being obtained with a one-pass tungsten inert gas (TIG) welding technique.

North American Aviation, Inc. is continuing with the dynamic portion of the CSM RCS coldflow breadboard tests. Recent tests indicate that the working pressure for the helium pressurization bottles on both CSM systems can be reduced from 5,000 to 4,500 psig. It has also been determined that the CM RCS propellant jettison system functions properly at design conditions. Some difficulty has been experienced in maintaining helium temperatures above freezing (32° F) during simulated propellant jettison tests. Further testing will be done in this area to determine if regulator freeze-up will occur during these "blow-downs." "Hot" firings of these breadboard systems are presently scheduled for initiation in the first quarter of 1964.

Service Propulsion System

The SPS provides power for all major velocity corrections after booster separation and for retrograde from earth orbit. This system also provides the velocity increments required for orbital correction.

The Arnold Engineering and Development Center (AEDC) conducted seven firings, primarily to check out test cell modifications and to demonstrate the capability of the test facility to test the 60:1 exit ratio nozzle extension. Various modifications of the facility and engine control systems, test cell exhauster system, and operating procedures were accomplished until, following the seventh run, the test configuration and procedures were considered adequate for performing the planned engine development tests using the columbium-titanium nozzle extension. Each checkout test was conducted with all titanium nozzle extensions to preclude destruction of the more costly columbium-titanium nozzle extention. Leakage through the thrust chamber valve ball seals necessitated the replacement of four engine valves and created a major delay in the test activities because of the replacement time required and the unavailability of spare units. Action was taken to improve the deficient seal design; to increase the number of spare valve units available on site at AEDC; and, if necessary, to replace the engine valve with a facility type valve. In addition, an apparent manpower shortage in the ARO, Incorporated, organization prevented the timely repair of facility equipment failures and the correction of facility configuration deficiencies. This problem is outside direct NASA control and may require corrective action by the USAF Systems Command.

On July 15, 1963, a doublet pattern with swirl type film cooling was selected as the prototype injector pattern on the basis of satisfactory ablative chamber compatibility and c* (characteristic exhaust velocity) performance of 96.3 percent of theoretical. Subsequent testing demonstrated adequate ablative chamber life and acceptable performance degradation under normal and abnormal operation duty cycles. The major problem remaining was the rating of the dynamic stability characteristics of the selected pattern against formal stability test criteria. MSC is developing such criteria at the close of this reporting period. These criteria will be incorporated into the engine development program requirements in October 1963.

The F-1 test fixture simulating spacecraft configuration propellant pressurant systems were installed on the C-11 test stand at the Aerojet-Sacramento, California plant and the first hot firing was conducted on September 28, 1963. In this reporting period subcontractors were selected for the remaining SPS components, and all but one were approved and signed.

Development and manufacturing are proceeding on all components with the exception of the helium solenoid valve which will be awarded soon. The first prototype helium regulator was completed and tested, and it performed within specifications.

The high velocity particle impact tests on propellant tank material samples being conducted at Salt Lake City, Utah have produced no acceptable data. Further tests will be made in an effort to obtain three acceptable impacts. Four helium tanks have been manufactured to date with one major weld problem reported. Corrective action consists of improving control of weld cleanliness. Two propellant tanks have been completed with some minor porosity in a weld on one of the tanks and a major problem of lack of filler material in a weld on the other tank. The first tank completed was a fuel tank; it began qualification testing on September 30, 1963. The tests were terminated when the tank developed a small crack near the bottom weld in the tank wall following proof test. Investigation into the cause of failure is now underway, and the results of which will be reported in the next status report.

Operational Instrumentation System

All AFM 009 transducer specifications are in various stages of the North American Aviation, Inc. release and review system. No contracts have been released.

The central timing equipment (CTE) is scheduled to begin acceptance tests at Elgin as soon as reported shortages of Hughes pins are resolved.

Leach Corp. is now working of the fabrication of the fourth Engineering (E) model of the data storage equipment (DSE). Models E-1 through E-3 have been through acceptance tests. Model E-3 was demonstrated to North American Aviation, Inc. and NASA at North American Aviation, Inc. in September 1963. Leach Corp. is in stages of completing the design of the three-speed DSE.

The completion of the first E model of the signal conditioning equipment is scheduled for late October 1963. The pacing items are signal conditioning modules from the companies of Vector, Epsco and United Electro Dynamics, scheduled for delivery to Collins Radio Co. on October 15, 1963.

The release of the radiation system specifications is planned for October 1963. North American Aviation, Inc. is presently completing additional studies requested by MSC.

The data distribution panel philosophy presently encompasses the following:

I. Operational distribution panel (behind tape recorder)

  A. Accessible: Approximately 1,700 data points

  B. Inaccessible: Approximately 1,200 data points

II. Flight qualification data distribution panels

  A. One located in the spacecraft electronic package with the flight qualification telemetry system

  B. The second located in the outer torroidal section of the CM along with the flight qualification commutators.

A joint Bellcomm, Inc.-Rand Corp. in-flight test study was released during this period with recommendations largely supporting the North American Aviation, Inc. in-flight test system (IFTS) concept.

The IFTS procurement was released by MSC on September 22, 1963. The Kellogg Division of International Telephone and Telegraph, Inc., has been awarded the IFTS subcontract. The present North American Aviation, Inc. in-flight maintenance and sparing concept is being reviewed by MSC.

The IFTS has been further defined as having 150 comparators instead of the original 225. The IFTS meter will have the capability of monitoring signals on all "GSE access" connectors of CSM equipment in the lower equipment bay. This additional meter capability is provided at little weight expense.

The CTE digital display has been replaced with a mechanical clock. This resulted in both a weight and power saving for the CSM.

Procurement specifications for the display and control panel components have been released except those for the incandescent bulb, hermetically sealed push button switch, and the hermetically sealed potentiometer. These are expected to be released during Ocotber 1963.

Purchase orders have been issued for the barometric indicator and for all panel meters.

Electrical Power System

The electrical power system (EPS) provides the ac and dc electrical power required by the various spacecraft systems during flight and postlanding phases of missions. Present status of the EPS is as follows:

Inverter.- Westinghouse Electric Co. has frozen design of the spacecraft prototype inverter. Westinghouse Electric Co. has officially requested the following deviations from the procurement specification:

Efficiency: 77.5 percent at 1,250 VA and 0.9 power factor. The specification required is 80 percent.

Weight: Maximum 40.3 lbs. The specification weight is 30 lbs.

Reliability: 0.9596 for 336 hrs. The specification reliability is 0.9786.

The affect of these deviations on spacecraft performance is presently being investigated.

Battery.- Five pre-prototype batteries have completed testing cycles at Eagle-Pitcher with no major design problems. Acceptable processes for welding and coating the titanium battery cases have been developed. The pruchase order for the pyro battery has been approved and is presently in the North American Aviation, Inc. procurement cycle.

Battery Charger.- Identification and traceability requirements placed on the International Telephone and Telegraph, Inc. battery charger have been resolved. First prototype unit is scheduled to be delivered during October 1963.

A decision has been made to make the portable life support system (PLSS) back pack battery compatible to the spacecraft battery charger, thereby deleting the requirement for the additional charger control unit.

North American Aviation, Inc. has been requested to provide electrical ground power through the SM umbilical connector in lieu of a carry-on cable, which would require removal prior to service tower removal. This change will save approximately three hours of spacecraft operational cryogenics and provide greater operational flexibility by making fuel cell start-up time independent of service structure removal time.

Total electrical energy requirements for the 14-day lunar mission are 581 kilowatt hours, which is approximately 80 KWH less than the previously reported power requirements, and is 51 KWH more than the existing fuel cell capacity of 530 KWH.

Entry time (CM-SM separation to touchdown) has been increased from 0.47 to 0.75 hours. The total estimated energy requirement for 0.75 hours is only within the combined capacity of the three present entry batteries. For emergency entry (two batteries, full charge) requires 1,544 watt-hours and only 1,450 watt-hours are available. Further increase of entry time will require an increase in entry battery capacity.

Fuel Cell.- Cell shorting and cell flooding continue to be the major causes of fuel cell malfunction. A number of failures have caused contamination of the product water due to the presence of KOH electrolyte. An extensive seal evaluation program has resulted in the present prestressed, molded Teflon "L" shaped seal configuration. Although this seal has greatly reduced the incidence of KOH leakage, it has not completely eliminated the problem. Seal development effort is continuing. A number of design modifications are now being made to the fuel cell module to eliminate causes of cell shorting and flooding. The table on the following page is an accumulation of test hours as of September 1, 1963.

Configuration	Test Hours		
	At Temp.	On Load	On Load W/O Malfunction
Single cells	approx. 48,000		
6 Cell stacks	5,690	3,487	
31 Cell stacks	2,758	870	
Independent modules	2,192	1,036	932

Cryogenic Storage System.- Metallurgical problems with both the titanium forgings for the H_2 pressure vessel and the Inconel 718 forgings for the O_2 pressure vessels have caused all present forgings to be rejected. The main problem has been extremely large material grain sizes which on one Inconel tank extended through the entire thickness of the pressure vessel wall. Titanium material has been ordered from a new forging vendor with a much improved forging process. A "creep" has been found on the 5Al, 2.5 Sn (ELI) titanium material being used for the H_2 pressure vessels. Wall thickness has been increased to prevent stressing the material above 75 percent of yeild at proof pressures. Machine tolerances have also been increased in order to reduce machining rejection rates which have been an estimated 75 percent. Two engineering model H_2 tanks have been fabricated from the "old" forgings. Tests such as fill, standby, and heat leak are being conducted. No O_2 tanks have been fabricated to date. Sufficient pressure vessel forgings have been salvaged to make H_2 and O_2 tanks for boilerplate 14 and AFRM 006 which do not require storage of cryogenic gases.

Communications System

The Collins Radio Co. definitive contract covering the CM communication equipment was reviewed by MSC and returned for appropriate action. The contract did not completely define the requirements for the negotiated dollar amount.

Radcom-Emertron, Inc. has stopped work on the C-band antenna pending completion of contract re-negotiations resulting from re-definition of thermal design and testing requirements. This is not expected to become a delivery problem.

The letter contract for the Up-Data Link was sent to Motorola, Inc. and their exceptions have been resolved. A meeting was held at North American Aviation, Inc. in which design details were discussed with Motorola, Inc.

Litton Industries, Inc. has been awarded a contract to develop an electrostatically focused klystron for a backup to the Hughes Aircraft Co. traveling wave tube. First delivery is expected in November 1963. Upon receipt, Collins Radio Company will begin design of an S-band power amplifier using the klystron.

The PAM/FM/FM telemetry system for boilerplate 14, AFRM 006, AFRM 008 and AFRM 009 to be used for flight qualification measurements will be NASA furnished.

Collins Radio Co. PERT has been fully implemented including the second tier subcontractor networks. Although negative slack is being currently reported, based on MDS-5 schedules, effort to reduce or eliminate further slippage is a major Collins Radio Co. management objective.

To better manage the parts procurement situation, Collins Radio Co. has written a computer program for its purchased and fabricated parts inventory and accounting system.

The communication and data system development status is as follows:

S-band power amplifier.- Model E-1 (first engineering model) is complete and is undergoing tests.

VHF recovery beacon.- Approximately 50 percent of the E model parts are at Collins Radio Co., and construction of E-1 is in process.

Pre-modulation processor.- Breadboard tests are complete, and E model construction is in process.

Audio center.- Model E-1 is complete, has undergone some pre-qualification tests, and is being used to check out the system test and maintenance unit (STMU) and to verify the checkout procedures. All the parts for model E-2 are at Collins Radio Company.

VHF/AM tranceiver.- Models E-1 and E-2 are complete except for parts shortages.

HF-transceiver.- Model E-1 is completed and is being checked out. Its associated STMU is complete and being used with E-1.

C-band transponder.- Model E-1 is complete and is undergoing tests.

E-2 and E-3 are being assembled. The C-band STMU is complete and is undergoing test.

Pulse code modulation telemetry.- Model E-1 is complete and is undergoing test.

Unified S-band equipment.- Assembly of E-1 and E-2 is well under way, and E-3 assembly has begun. Tests are continuing on the breadboard to reduce a few remaining problems.

VHF/FM transmitter.- Models E-1 and E-2 are complete and undergoing bench tests.

VHF multiplexer.- Model E-1 has been delivered to North American Aviation, Inc. for engineering tests. Model E-2 is nearing completion.

Ground support equipment (GSE).- Development models of the crystal controlled signal generator, the S-band phase-lock receiver and all STMU's except the pre-modulation processor are complete and undergoing tests.

Earth Landing System

The fifth test with boilerplate 3 was conducted September 6, 1963. This test was a repeat of conditions previously run, but without strakes and forward heat shield simulating the new boilerplate 6 configuration and tower flap concept. The vehicle was not recovered and is not repairable. Satisfactory recovery of boilerplate 3 was not achieved due to damage of the main parachute harness assembly with resulting structural failure allowing two of the main parachutes to separate from the vehicle. Damage of the main harness is attributed to structural degradation of the upper harness legs by the main parachute disconnect and abrasion over the vehicle structure in the gusset areas while at apex forward angles of attack. Boilerplate 19 will be used to complete the constraint testing prior to testing boilerplate 6.

The boilerplate 6 and the boilerplate 19 parachute systems differ from the spacecraft system. A rigid yoke replacing the harness system was in design at North American Aviation, Inc. prior to the boilerplate 3 drop. The rigid yoke will alleviate many of the difficulties experienced with boilerplate 3. A timing change for drogue parachute release has also been made to the boilerplate 19 and boilerplate 6 sequence controllers to achieve a more favorable CM attitude at pilot chute deployment.

Two simultaneous-deployed drogue parachutes are being incorporated in the spacecraft system to increase reliability. Two parachute-test-vehicle (PTV) drops were made at El Centro, California to assure feasibility of this configuration. Both drops were successful, and the dual drogue concept appears to be feasible.

Due to the poor cluster performance of the triconical solid parachute experienced in the tests at El Centro, California, the Pioneer solid parachute program has been canceled.

A main parachute wind tunnel test has been initiated at Ames Research Center. The objective of this test is to gain basic knowledge of the clustered parachute inflation characteristics which will aid in the reduction or elimination of the aerodynamic interference effects in the present Apollo system. Elimination of interference will result in a reduced parachute weight and provide a system with more predictable inflation characteristics.

Eight impact tests were conducted on hard-packed soil during this reporting period. All of these were conducted with the nominal pitch attitude of -30° at impact. The last test with boilerplate 1 was at a horizontal velocity of 51 fps and a roll angle of 70°. This was the first test at this high horizontal velocity. None of the crew couch attenuation struts bottomed. Preliminary drop test results extended to conditions not yet tested by computer analysis have shown that for hard-packed soil impacts, a probability of 0.9968 exists for not exceeding nominal limits corresponding to 0.9994 for not exceeding emergency limits. These results were obtained by using graduated core stiffness which results in several levels of crew acceleration during the stroke of the various shock struts with consideration given to the combinations of g levels occurring simultaneously in the different axes.

Significant areas to be defined include correlation of test results with airframe results, structural criteria based on test, and flotation characteristics under appropriate sea state conditions.

Difficulties in developing spacecraft cartridges for the drogue and pilot mortars caused slippage of boilerplate 6 flight. Principal problems are in a high reaction load on the pilot mortar and debris from the cartridge end closures. Interim cartridges will be used on the boilerplate 6 flight in October 1963.

The drogue disconnect failed on drop No. 4 of boilerplate 3. Main parachute deployment and recovery were normal. The failure has been attributed to an excessive wall thickness of the detonator; this is being corrected.

The main parachute disconnect is being completely redesigned in conjunction with the rigid yoke. The old disconnect has been deleted from all applications.

Configuration of the Earth Landing System is shown in figure 8.

Pyrotechnics

Solutions to most of the problems in development of the Apollo standard initiator have been found. The principal problem remaining is the sensitivity to static electrical discharge. To date about 60 tests have been made at voltages between 2,000 and 9,000 volts after other problems with instrumentation were solved. Several possible fixes are being studied and will be incorporated into early lots.

It has been determined that the Apollo standard detonator has excessive wall thickness which prevents reliable detonation of linear shaped charges. A thin-walled detonator is now on procurement.

North American Aviation, Inc. has been requested to establish, in its data center activity, complete traceability of all initiators from manufacture to final firing and to provide for complete data acquisition on all initiator firings.

Development of the dual separation mode explosive bolt for CM to launch escape tower separation was begun this quarter. One separation is accomplished by an internal explosive charge in the bolt. The redundant separation mode consists of cutting a flattened portion of the bolt with linear shaped charge.

Heat Shield

Differential thermal motion between the forward heat shield and the crew compartment heat shield has been minimized by redesign of the attachment of the forward heat shield. Warping of the cone may result in gaps and is under detailed evaluation. The joint between the crew compartment heat shield and the aft heat shield for the spacecraft now under contract is being designed to a criteria compatible with an earth orbit mission. Further development of this joint is required for the lunar mission and has been started by the AVCO Corporation.

The "gun" method of filling the honeycomb core with 5026-39 has been adopted as the fabrication technique. This process will result in a slight decrease in ablator density. The effect on the heat shield weight has not been evaluated at this time.

Revised heating rates due to increased CM weight have caused the design release date of the AFM 009 heat shield to be rescheduled from October 24, 1963, to December 12, 1963, with no significant effect on North American Aviation, Inc., Master Development Schedule No. 7.

An analytical and experimental effort is under way to define the thermal stresses induced in the cold soak condition and to define a satisfactory design criteria for this situation.

Adapter

The Saturn IB and V spacecraft adapter configuration has been established as a truncated cone 345 inches in length. The LEM support points are located such that LEM station 200 corresponds to spacecraft station 600. This configuration allows adequate clearance between the LEM and the service propulsion engine bell and between the LEM landing gear and the S-IVB instrument unit.

The C-1 adapter separation system has been designed. Two circumferential cuts will be made by linear shaped charge -- on the splice plate at the top of the adapter and on the sandwich at the bottom. Four longitudinal cuts will be made. Initial tests are in process.

LUNAR EXCURSION MODULE

The LEM is the space vehicle for transferring two of the three Apollo crew members and their payload from the CM in lunar orbit to the lunar surface and then returning them to the CM. Included in this operation are the functions of separation from the CM, lunar descent, lunar landing, ascent, and rendezvous and docking with the CM. Figure 9 illustrates the LEM configuration.

LEM Structure

The LEM will be supported in the spacecraft adapter by means of the fixed truss portion of the landing gear. This support method simplifies the LEM-SIVB separation system by allowing the lower portion of the adapter below the attach points to remain with the S-IVB after separation.

The extendible boom concept of module docking was selected as the design approach. All systems which are dependent on a docking concept will be configured to this design approach.

Grumman Aircraft Engineering Corp. and North American Aviation, Inc. have determined that the first bending mode frequency of the docked CM and LEM is on the order of 20 radians per second. North American Aviation, Inc. has determined that 40 radians/second is desired to prevent coupling with the thrust vector control system of the SM. Grumman Aircraft Engineering Corp. is studying LEM weight effects for increasing the frequency to the 40 radians/second.

The descent engine will be designed to allow crushing of the engine skirt in more adverse landing conditions. Clearance will be provided for the lower surface of the descent stage when all gears are fully compressed and the engine is positioned over a 24 inch high obstruction.

Proposals have been received by Grumman Aircraft Engineering Corp. for design, manufacture, and qualification testing of the descent stage propellant tanks. The proposals have been evaluated, and their recommendation has been forwarded to MSC.

Landing Gear

The present lunar landing gear is conceived as a deployable aluminum alloy truss structure with a semi-tread radius of 180 inches. An analytical effort has been initiated to define the stability limits of this gear configuration by varying those factors which primarily affect stability; such as lunar slope, touchdown velocity and direction, and effects of soils mechanics. This analytical program will directly support the $\frac{1}{6}$ scale model and full scale drop test programs.

The LEM $\frac{1}{6}$ scale model design and test program was reviewed with representatives from Langley Research Center and MSC. Agreement was reached for Grumman Aircraft Engineering Corp. to proceed with drawing release of the No. 2 model and was requested to submit a preliminary contract change proposal to furnish two additional $\frac{1}{6}$ models for tests by Langley Research Center Dynamic Loads Division and by MSC SEDD.

The LEM adapter support requirements and location were determined using the landing gear envelope required for a 180 inch radial fold gear. If required at a later date, using the same support points, the LEM adapter support has the capability to go to a 200 inch radius gear.

Crew Provisions

It has been established that a stand-up position for the crew at both stations is feasible considering the small load factors associated with the LEM mission. The arrangement permits a significant weight reduction, more efficient use of cabin volume, and improves crew visibility and mobility at the station. The concept has been approved and a simplified support-restraint system is being designed.

Food and first aid equipment as developed for CM utilization has long been recognized as LEM common usage items. Implementation of this objective with the CFE introduces a number of development, procurement, and delivery complications. The objective is much more readily achieved with the GFE via North American Aviation, Inc. in that the supplier of the items is responsible to a single contractor, sole source justification is eliminated and operationally provisioning of the spacecraft is simplified. This then is the preferred and now directed technical approach.

An initial conference between LEM contractor and Wright-Patterson AFB personnel has been held to familarize Grumman Aircraft Engineering Corp. with facilities, capabilities, procedures and previous effort in zero "G" testing. Lines of communications were established and the preliminaries to actual test planning were completed.

A series of helicopter flights conducted by MSC Flight Crew Operations Division at the request of the Apollo Spacecraft Project Office to explore LEM window requirements has been completed. It is important that the data yield be recognized as an indicator only, since test procedures could not include all facets of the problem. The results did indicate that the current LEM window geometry is adequate for pursuing into a detail design and more extensive evaluation. Additional work is required in this area to achieve an understanding of the crew's capabilities in an unfamiliar environment.

Grumman Aircraft Engineering Corp. was asked to explore the feasibility of the LEM crew assuming a standing position during flight as opposed to conventional seating. The objectives were to improve visibility, mobility in cabin, ingress/egress at crew station and reduce weight. Grumman Aircraft Engineering Corp. has verified that the concept is sound. They depicted a preliminary hardware configuration during the September 17, 1963 mock-up review.

The computer program currently being employed by Grumman Aircraft Engineering Corp. for crew task analysis is limited in scope to the nominal mission. Assessing mission contingency effects on crew duties is required and it is felt the computer program can be extended to include this capability. Grumman Aircraft Engineering Corp. has been asked to determine the effort required to do this.

The present location of the RCS thrusters places them in the visual field of the crew. During thruster firing, the plume is transparent and creates no visual interference. The thrusters, however, flow with sufficient brightness to destroy the crew's dark adaptation and must, therefore, be shielded.

As stated in the summary, a formal review of the Grumman Aircraft Engineering Corp. M-1 mock-up was held on September 16, 17, and 18, 1963 by NASA personnel.

A total of 33 chits were submitted during the review, 11 of which were duplications. Of the remaining chits, the review board made the following disposition: 16 required Grumman Aircraft Engineering Corp. compliance, 2 required MSC review and response, 1 required a Grumman Aircraft Engineering Corp. review and response, and 3 were disapproved. A detailed board report is being prepared for submittal to Grumman Aircraft Engineering Corp. with recommended action.

Environmental Control System

Hamilton Standard Division of United Aircraft Corporation was authorized by Grumman Aircraft Engineering Corp. to proceed on July 22, 1963, in accordance with agreements reached in negotiations for a CPIF subcontract for the LEM ECS. Design control specification LSP 330-2A, dated August 2, 1963, establishes the requirements for those sections of the ECS to be supplied by Hamilton Standard Division.

Preliminary design studies indicate that the LEM suit circuit compressor could be designed to allow physical interchangeability with the CM compressor. However, Grumman Aircraft Engineering Corp. does not recommend changing the present radial flow design to the axial flow design required to allow interchangeability because of the power increase associated with the lesser efficiency of the axial flow design. MSC concurred with this recommendation.

Guidance and Navigation

Radical telescope changes by MIT with a resulting change by Grumman Aircraft Engineering Corporation of some LEM operating concepts have occurred and Grumman Aircraft Engineering Corporation is evaluating the impact.

Statements of Work for LEM guidance and navigation concept design were agreed upon. Technical directives covering most of the work have been received by the contractors.

LEM guidance and navigation System requirements and delivery schedules were provided to A.C. Spark Plug, Raytheon Corporation and Kollsman Instrument Co. These will be used as a basis for bids for LEM development and hardware.

The LEM guidance and navigation hardware procurement plan is as yet unapproved by NASA Headquarters.

A study replacing the rendezvous X-band radar on the LEM and CSM with a unified S-band system has been initiated. The primary questions at this point seem to be the angle accuracy available from S-band interferometer antenna and the refraction in the rocket plume.

Stabilization and Control System

A meeting was held with Grumman Aircraft Engineering Corporation to discuss mechanization problems of the attitude display. Two approaches that appear feasible are transformation of attitude reference gimbal order for display, and 90° rotation of the attitude display instrument in LEM. The first method requires considerable complexity in the reference display interface. The second method may create crew training problems. Studies are continuing toward resolution of this display.

The control electronics functional description document, LMO 300-33, was reviewed with Grumman Aircraft Engineering Corporation. General agreement was made with respect to the design approach. Further definition will be required prior to specification approvals.

The thrust vector control report, LED 290-2, was reviewed and comments transmitted to Grumman Aircraft Engineering Corporation.

Representatives of STD, ASPO and Grumman Aircraft Engineering Corporation attended a meeting held at Grumman Aircraft Engineering Corporation to review reaction jet modulation techniques. It was generally concluded that the pulse ratio modulation (PRM) approach is most desirable for the LEM/SCS. A non-linear PRM technique is being implemented.

Difficulties have been experienced in implementing common usage of rotation hand controller. Grumman Aircraft Engineering Corporation has been requested to implement the Gemini type rotation controller and to work closely with North American Aviation, Inc. so that a maximum of design commonality can be achieved.

A meeting was held at Minneapolis-Honeywell Regulator Co. with personnel from the following contractors:

1. Grumman Aircraft Engineering Corporation
2. North American Aviation, Inc.
3. Minneapolis-Honeywell Regulator Company
4. ASPO

The purpose of the meeting was to provide Grumman Aircraft Engineering Corporation with detail information of CM/SM jet drivers and demodulators for common usage implementation.

The revised PERT network was reviewed prior to formal submittal to MSC. The network has been significantly improved over the previous issue, although some assemblies of the SCS are yet to be added.

Grumman Aircraft Engineering Corporation has been given direction to prepare separate specifications for the SCS and RCS; they have been considering integrating requirements into a single flight control system specification.

The functional description document for the back-up guidance section is being reviewed within MSC. Efforts to obtain the attitude reference assembly (ARA) procurement specification for MSC review have been unsuccessful. Grumman Aircraft Engineering Corporation has stated the specification will not be released to MSC until the complete vendor requirements document is released for bids.

Reaction Control System

The primary efforts during the past quarter have involved definition of component performance characteristics, preparation of procurement specifications, and initiation of development testing on the helium pressurization system. Subsequent to the last report, the decision was made to combine the RCS and main propulsion breadboard system test areas at Grumman Aircraft Engineering Corporation, resulting in a scheduled date of November 1, 1963, for starting RCS cold flow breadboard testing. This schedule reflects a delay of approximately eight weeks, which will be partially compensated for by increased emphasis on the helium blow-down rig tests.

Fabrication of the helium blow-down rig has been completed, and delivery of the initial "workhorse" components began in late September 1963. The workhorse components are heavyweight, off-the-shelf items for use in verifying the subsystem design approach and the required component performance requirements. Testing with these components will begin the first week of October 1963. The blow-down rig will continue in use to resolve individual component performance characteristics after start of breadboard testing.

Subcontract arrangements between Grumman Aircraft Engineering Corp. and Marquardt Corporation for the engine cluster assembly and control valves were completed in mid-July 1963. Marguardt Corporation's major efforts at this time include definition of thermal control design requirements for the cluster and activation of test cells for cluster development and hot firing breadboard system testing. The development status of the common use RCS engine is reported under the SM reaction system.

Preparation of procurement specifications for flight weight pressurization system components is approximately fifty percent complete. The specifications for the longest lead time items, tanks and quantity gaging are in final review as of the date of this report. Grumman Aircraft Engineering Corp.'s procurement action of these components will be delayed by twelve to fifteen weeks as a result of underestimating the time required to prepare and process the specifications. This delay does not jeopardize the subsystem qualification schedule, although it will result in curtailment of subsystem testing with flight weight components prior to entering the design verification test phase. Design verification testing is an interim phase designed to assure that the RCS is ready for integrated testing with the ascent propulsion subsystem.

Plans for the next quarter include completion of procurement specifications, blow-down rig and cold flow breadboard testing at Grumman Aircraft Engineering Corp., cluster development testing at Marquardt Corporation, and hydrodynamic and thermal analysis of the subsystem.

Propulsion System

General.- Ascent stage heavyweight rig HA-1 has the propellant tanks installed and is being plumbed with off-the-shelf components. The descent stage heavyweight rig HD-1 is in manufacturing with tanks and components not yet available.

Grumman Aircraft Engineering Corp. is awaiting delivery of plexiglas tanks for the slosh rig tests. These tanks were redesigned for ease of fabrication, and then were further delayed due to unavailability of a suitable plexiglas material.

Descent Propulsion.- Grumman Aircraft Engineering Corp. has completed negotiations with Space Technology Laboratory (STL) for development of the mechanically throttled LEM descent engine. A go-ahead was given to STL to begin work in early July 1963. Firings are being conducted on a 5,000 pound thrust engine to investigate design parameters for the throttling injector. Firings are also being made on a thrust chamber with a one inch throat for the proposed materials evaluation. A total of 65 tests are planned on this thrust chamber, of which 45 tests have been completed. The first firing of a 10,500 pound workhorse thrust chamber and injector was made on September 21, 1963.

Workhorse chamber, injector and propellant valve drawings were released by Rocketdyne Division, and the first workhorse thrust chamber and injector test was accomplished. This test utilized an ablative chamber designed for 1,000 seconds life and a modified Nomad injector with a film cooled, high performance showerhead pattern. Additional firings were made with further modifications to the injector.

Ascent Propulsion.- Grumman Aircraft Engineering Corporation issued a development go-ahead to Bell Aerosystems Company on July 3, 1963, for the fixed thrust ascent engine. Bell Aerosystems Company is currently conducting parametric studies of engine operating characteristics utilizing a 3,000 pound thrust engine. An ablative materials evaluation is being conducted on chambers supplied by AVCO Corp., HITCO, and TAPCO, using a modified Agena injector. As of the date of this report, four firings each have been made on the AVCO Corp. and HITCO chambers. Analysis of test data has not been completed.

Following completion of studies by Grumman Aircraft Engineering Corp. and MSC, Grumman Aircraft Engineering Corp. was directed to pursue the ablative nozzle extension as the primary design approach. MSC studies indicate that the ablative nozzle extension represents the most reliable and least complex design for the ascent engine. Limited design effort on the radiation cooled extension will be continued as a potential weight savings program.

Communications Subsystem

Grumman Aircraft Engineering Corp. released the communications subsystem vendor requirements package (VRP) - less the VHF antennas and the S-band omni antenna - to Radio Corporation of America on August 20, 1963. Expected vendors are:

TV cameras - Radio Corporation of America
S-band diplexer - Rantec
S-band transponder - Motorola, Inc.
S-band power amplifier - Raytheon Co.
S-band steerable antenna - Possible common usage (Avien)
S-band erectable - Unknown
Audio center - Collins Radio Co.
Pre-modulation processor - Collins Radio Co.
VHF transceiver - Probably Radio Corporation of America
VHF diplexer - Probably Radio Corporation of America

Radio Corporation of America's proposal is expected by October 15, 1963 and negotiations are expected to begin by October 22, 1963, with contract go-ahead expected by November 19, 1963. Radio Corporation of America has already contracted the vendors shown above for proposals. MSC has submitted its comments to Grumman Aircraft Engineering Corp. on this VRP.

A study is presently underway to determine the optimum low-level TV sensor for use on the lunar surface. The two leading contenders at this time are Radio Corporation of America's image intensifier - vidicon combination and Westinghouse Electric Co.'s secondary emission conductivity (SEC) tube. The SEC tube is presently the more desirable. A decision will be made on which tube Grumman Aircraft Engineering Co.

will specify by October 20, 1963.

Grumman Aircraft Engineering Co. is currently conducting $\frac{1}{10}$ scale LEM model VHF antenna pattern studies in order to optimize the LEM VHF antenna configuration. S-band studies are awaiting completion of a $\frac{1}{6}$ scale LEM model.

Grumman Aircraft Engineering Corp. has been directed to implement MIL-I-26600 with an MSC modification as the LEM electromagnetic interference (EMI) specification. Grumman Aircraft Engineering Corp. is expected to request certain minor changes to this specification. Grumman Aircraft Engineering Corp.'s EMI test plan has been reviewed by the LEM Engineering Office and found to be satisfactory at this time, pending further development and elaboration.

An investigation is currently underway to determine the feasibility of using the Unified S-band equipment for rendezvous in place of the present X-band system.

Operational Instrumentation Subsystem

Grumman Aircraft Engineering Corp. released the pulse code modulation and timing equipment (PCMTE) VRP to Radiation, Inc., on August 19, 1963. Radiation, Inc. submitted a proposal to Grumman Aircraft Engineering Corp. on September 10, 1963. Negotiations are expected to begin on October 7, 1963 with vendor go-ahead expected by November 4, 1963. MSC has submitted its comments to Grumman Aircraft Engineering Corp. on this VRP.

Grumman Aircraft Engineering Corp. released the DSE VRP to Leach, Inc., on August 29, 1963. Leach Inc. is expected to submit their proposal to Grumman Aircraft Engineering Corp. by October 13, 1963, with negotiations to begin on October 20, 1963. Contract go-ahead is expected by November 21, 1963. MSC has submitted its comments to Grumman Aircraft Engineering Corp. on this VRP.

Development of the instrumentation subsystem PERT is progressing at a satisfactory rate and is presently operational. Further development is required in the measurement systems fragnets.

Francis Associates, Inc., will complete its LEM electronics packaging study in early October 1963 and will, with Grumman Aircraft Engineering Corp., present its proposed packaging technique to MSC in late October 1963. There will be very little in-flight replaceability of parts capability in either the LEM instrumentation or communications subsystems.

Criteria, ground rules and requirements of the LEM status system are presently being developed by MSC and Grumman Aircraft Engineering Corp.

Electrical Power System

Power Distribution.- The Grumman Aircraft Engineering Corp. load analysis of subsystem electrical energy requirements indicates that the electrical energy required for the complete LEM mission is 76.52 KWHRs. Subsystem electrical energy requirements are as follows:

Communications	9.01 KWHR
Crew systems	1.30 KWHR
Displays	2.44 KWHR
Environmental control	16.13 KWHR
Electrical power	14.75 KWHR
Instrumentation	17.41 KWHR
Navigation and guidance	12.42 KWHR
Propulsion	0.07 KWHR
Reaction control	0.13 KWHR
Stabilization and control	2.86 KWHR
Total	76.52 KWHR

Revisions to subsystem electrical energy status, reapportionment of control energy levels, and establishment of realistic essential and emergency power profiles is dependent upon completion of the LEM weight study program and establishment of the new mission profile. A group of electrical power meetings are planned during November 1963 for the purpose of reviewing subsystem power requirements, and to evaluate possible methods of reducing power requirements.

Grumman Aircraft Engineering Corp. has completed a preliminary design of the LEM d.c. distribution system, which includes an essential buss, a non-essential buss, a control buss, and a spike buss. The preliminary distribution system provides features for manual control, for isolating trouble, and is designed to actuate switches and breakers under out of tolerance conditions include a feeder control logic circuit and a distribution control logic circuit. Grumman Aircraft Engineering Corp. has reduced the inverter study to two candidate configurations which are going through a weight and reliability evaluation. One system is semi-centralized and consists of two inverter types; one would be synchronized with the navigation and guidance clock with phase and frequency synchronization for close tolerance loads, and the other would be synchronized with the instrumentation clock and would supply ac loads requiring only frequency synchronization. The second inverter system under consideration is decentralized and consists of one inverter type which would supply ac loads requiring only frequency synchronization.

All other loads would be supplied dc power. Power conditioning would be done within systems or equipments. Completion of the inverter study is anticipated by November 15, 1963.

The Grumman Aircraft Engineering Corp. study of LEM interior lighting system configuration, and lighting power and control has been completed. The most promising interior lighting system configuration continues to be electrolumnescent panel lighting with floodlighting back-up. Selection of interior lighting system configuration is dependent upon inputs from human factors engineers regarding color and brightness, and completion of shock and vibration tests of incandescent lamps. Resolution of all interior lighting design considerations is anticipated by the first of November 1963.

The specification and vendor requirements for the LEM auxiliary battery were released on July 29, 1963. Vendor proposals have been received and are being evaluated. However, completion of evaluation and vendor selection is dependent upon MSC review of the Grumman Aircraft Engineering Corp. recommendations for a change to a power source configuration of two fuel cells supplemented by an auxiliary battery system.

<u>Power Generation</u>.- Grumman Aircraft Engineering Corp. completed contract negotiations with Pratt and Whitney Aircraft for the development and qualification of a 900 watt fuel cell assembly (FCA) for LEM, and delivery of 60 FCA's for ground testing and flight vehicles. Subsequent to MSC review of negotiation results, a letter go-ahead was given to Pratt and Whitney Aircraft on September 5, 1963.

The electrical power source for the LEM currently consists of three FCA's rated at 900 watts for continuous operation. The reactant oxygen is integrated with the ECS oxygen in a descent stage supercritical cryogenic oxygen (SOX) tank. Reactant oxygen used after lunar launch is stored in a SOX tank in the ascent stage. After selection of the Pratt and Whitney Aircraft open-cycle fuel cell, a staged hydrogen tank configuration was selected which consists of a large supercritical storage vessel in the descent stage and two equal size tanks in the ascent stage.

A requirement specification and VRD for the cryogenic tank assemblies were prepared by Grumman Aircraft Engineering Corp. and released for bid on September 9, 1963. Proposals from potential tank manufacturers were received for evaluation September 30, 1963.

A weight - reliability trade-off study is in progress at Grumman Aircraft Engineering Corp., aimed at reducing subsystem weight. Eighteen candidate configurations in addition to the current one are under consideration. These candidates consist of various combinations of fuel cells, staged and unstaged tankage. MSC is currently reviewing a recommendation by Grumman Aircraft Engineering Corp. to change to a two-fuel cell configuration supplemented by an auxiliary battery system.

Grumman Aircraft Engineering Corp. has completed a preliminary test plan for the power generation section (PGS), covering Grumman Aircraft Engineering Corp. in-house development, design verification and qualification testing. This plan develops the test logic for integration of LEM test article (LTA) and LEM testing to establish system integrity.

SPACE SUIT

The first prototype Apollo space suit was delivered in August 1963. The following MSC in-house evaluation have been sustantially completed:

a. Mobility

b. Metabolic heat production

c. Vision

d. Operation of secondary protection

e. Donning/doffing

f. Short term comfort

g. Physical tests (leakage, overpressure, etc.)

The following tests are planned for October and November 1963:

a. Spacecraft mobility/compatibility tests in CM and LEM mockups.

b. Centrifuge evaluation

c. Zero-g performance (KC-135 flights)

The Apollo space suit is the first space suit ever developed which has a secondary full pressure protection requirement; preliminary evaluation indicates satisfactory operation of the secondary system with some degradation of mobility.

The suit entrance design eliminates the need for pressure sealing zippers; evaluation indicates that the new closure design will function satisfactorily.

During the evaluation, the suit had two failures associated with restraint cable attachment; the failures are now under study.

MSC received the first prototype PLSS on September 23, 1963.

Design of the portable life battery was changed from a 17 volt, 11 cell battery to a 28 volt, 20 cell battery; reason for change was to simplify battery charging equipment aboard the spacecraft.

R AND D INSTRUMENTATION/COMMUNICATIONS SYSTEM

Command and Service Module

Government furnished airborne equipment (GFAE) for Apollo boilerplates 6, 12, 13, 23, and 15 have been delivered to North American Aviation, Inc. Boilerplate 22 GFAE is now undergoing breadboard testing and is scheduled for delivery to North American Aviation, Inc. on December 13, 1963. Boilerplate 18 GFAE is undergoing flight qualification and is scheduled for delivery to North American Aviation, Inc. on December 27, 1963.

GFAE is now scheduled to completely support the AFRM 002 and 010 communications/instrumentation requirements and to partially support boilerplate 14, AFRM 006, AFRM 008, AFRM 009 and AFRM 011 in the area of flight qualification telemetry systems.

Lunar Excursion Module

Two measurements meetings for LEM 1 and 2 have been held to date with the result that the measurement requirements list has not yet been reduced to an acceptable level. Procurement action must proceed immediately to avoid possible schedule slippages. It is expected that procurement action will be stopped on unnecessary transducers prior to actual contract release.

Preliminary equipment handling procedures and contractor/NASA working relationship documents have been drawn up and are now being negotiated between the involved parties.

SCIENTIFIC INSTRUMENTATION PAYLOAD

The primary MSC organization presently involved in definitizing the Apollo scientific payload is Space Environment Division. This division is presently conducting studies to determine the optimum payload for a lunar landing mission and will be instrumental in making available the required hardware.

Present LEM weight, power and volume allocations are as follows:

Ascent Stage (Cabin)

Specimen return container (SRC) - 2 cubic feet
eighty pounds (lunar liftoff)

Cameras - 9" × 8" × 3", 4 pounds
9" × 7" × 4", 5 pounds

Descent Stage

Scientific equipment - 10 cubic feet
241 pounds

Twenty-four hundred watt-hours of LEM dc power are allocated to the scientific payload. The shape of the SRC is presently under negotiation to insure its compatibility with both the LEM and CSM.

CSM space, weight and volume allocations for scientific equipment will be made on a per-flight, as required basis.

APOLLO SPACECRAFT WEIGHT

Table I, on the next page, gives the control weights, the design goal weights, and the status and changes of the current spacecraft weights. Deletion of the 500 pound LES effective weight penalty made possible a 70 pound increase in the inert control weight of the LEM ascent stage. This required increase usable propellants in the ascent stage (80 pounds), descent stage (180 pounds) and SPS (170 pounds). The LEM design goal weight was established at 25,000 pounds, 500 pounds over the previously estimated value. This required 235 pounds of additional SPS propellant. The LES effective weight penalty was also deleted from the design goal and current weight breakdown. The distribution of LEM weight between ascent and descent stage is presented for the first time in the control and design goal weight breakdowns.

Command Module

The major changes in the CM were due to the addition of the up-data link, an increase in the nuclear radiation detection system, incorporation of the two point parachute attachment, an increase in strake structure resulting from antenna relocation, structural increases due to heat shield structure design for thermal and cold soak conditions, revised controls and displays, and addition of RCS propellant dumping provisions.

Service Module

The total weight change to the SM during this quarter was an increase of sixty pounds. The major weight increases were due to fuel cell power pack, more detailed evaluation of instrumentation wiring and provisions, addition of motor switches in lieu of relays for power distribution system, and revised estimate electrical harnesses, plumbing and valves for the main engine. The decreases resulted from current calculations of structural drawings, reduction of external insulation for the RCS engine plumes and design refinements of the ECS and EPS space radiation.

Launch Escape Motor

The major changes to the LES were due to increases in tower insulation thickness and ballast weight consistent with combined CM and LES balance requirements.

Saturn V Adapter

The adapter weight has been increased due to revised configuration for compatibility with the LEM.

Lunar Excursion Module

In general, the LEM weight increase results from refinement of subsystems design. Structure weight increase with establishment of the cabin configuration. Navigation and guidance weights increased with definition of a system for LEM (the weight of the system is being refined to a lower value). Present ECS weight increase reflects subcontracted component weights. The folding gear concept has increased gear weight (the previous estimate of the gear was extremely low). Operational instrumentation weight has increased with definition of system requirements. Electrical power supply weight increase is primarily in the distribution system. Propulsion system design has firmed as components were subcontracted resulting in weight increases. Propellant tanks are sizes for a 28,000 lb LEM. Propellant requirements have increased as a function of inert weight. RCS system has increased with system definition. Tanks are sized to contain rendezvous and docking propellant. Propellant requirements are also related to performance of this function with RCS. Spares not formerly reported are now included.

[redacted]

TABLE I.- APOLLO SPACECRAFT WEIGHT STATUS

Lunar Orbit Rendezvous Mission

	Control Weight, lb		Design Goal, lb		Current Weight, lb		Change From Last Report, lb		Remarks
A. Command Module (including crew)		9,500		8,500		9,650		+480	
B. Service Module		50,400		45,850		49,491		+2,261	ΔV margin = 10%
Inert	10,500		9,500		9,680		+60		
Usable [a]SPS propellant (ΔV_1 = 3,883 fps)	27,700		25,370		28,015		+1,865		
Usable SPS propellant (ΔV = 4,801 fps)	12,200		10,980		11,796		+336		[b]SPS I_{sp} = 313.0 sec
Total	50,400		45,850		49,491		+2,261		
C. Lunar Excursion Module (w/o crew)		26,700		25,000		28,476		+3,076	ΔV margin = 10%
Descent stage inert	3,640		3,550		3,281		+124		[c]DSC I_{sp} = 305.0 sec
Usable propellant (ΔV = 7,827 fps)	14,900		13,950		[e]15,474		+1,261		
Ascent stage inert	3,970		3,675		5,392		+1,750		[d]ASC I_{sp} = 303.0 sec
Usable propellant (ΔV = 7,079 fps)	4,190		3,825		[f]4,329		-59		
Total	26,700		25,000		28,476		+3,076		
D. Adapter		3,400		3,000		3,400		+290	
E. Total Spacecraft Injection Weight		90,000		82,350		91,017		+6,607	
Launch Escape System Weight		6,600		6,400		6,650		+260	
Total Launch Weight		96,600		88,750		97,667		+6,367	

[a]SPS = Service Propulsion System

[b]I_{sp} = Specific Impulse

[c]DSC = Descent Stage of Lunar Excursion Module

[d]ACS = Ascent Stage of Lunar Excursion Module

[e]7,540 fps ΔV available

[f]6,030 fps ΔV available

NOTE: A propellant and tankage weight increase to meet the required ΔV with the current LEM inert weight may result in a total LEM weight of approximately 31,500 pounds and an escape weight of approximately 92,500 pounds based on current weights.

[redacted]

FLIGHT TECHNOLOGY

Aerodynamics

During the past quarter, the decision was made to remove the aerodynamic strakes. The reason for this decision was due to the continued forward movement of the center of gravity which, in turn, resulted in greater strake area to eliminate the apex-forward trim point. The larger strake area in addition to the adverse CM heating characteristics associated with the strakes resulted in an unacceptable CM weight increase. For this reason, several alternative solutions of the apex-forward trim problem were investigated by North American Aviation, Inc. These investigations have led to the selection of the "tower flap dual mode" approach. This concept incorporates fixed surfaces at the upper end of the tower, which are exposed to the air stream by jettison of the expended rocket casing. In order to assure proper jettison of the apex cover during low altitude aborts, a second mode of operation is employed for aborts below 30,000 feet. Instead of jettisoning the rocket motor casing, the jettison motor is used to pull away the expended motor casing, the tower, and the apex cover.

An extensive wind tunnel program has been completed to define the configuration of the tower flap. Data are now being reduced and a final configuration selection is expected during the next month.

An independent investigation of another solution to the apex-forward trim point is being undertaken by MSC as a backup to the North American Aviation, Inc. program. This investigation is centered around the concept of deployable aerodynamic surfaces at the forward end of the LES rocket motor. These surfaces would be deployed after LES burnout and would cause the launch escape vehicle to trim in the heat shield forward position. Completion of the independent investigation is expected during the next quarter.

Aerodynamic Heat Transfer

A five volume summary of the estimated boost and reentry heating characteristics has been issued by North American Aviation, Inc. and is being incorporated into the heat shield design by AVCO Corporation. This report gives the time history of cold wall heating rates at 62 body locations for all of the heat shield design trajectories. Emphasis is now being placed on the more accurate definition of the heating rates to be expected in and around holes and protuberances on the CM.

Ablation Material Thermal Performance

During the last quarter, an experimental program has been conducted to define the influence on thermal performance due to change in the ablator manufacturing process from a tamping process to a pressurized gun process. No significant changes in the materials performance were indicated by the AVCO Corporation tests.

Two of the four Scout nose caps for the materials flight test program have been delivered to Langley Research Center. A third cap is being completed at the present time. The fourth cap is being reworked in order to have the instrumentation plugs changed to material manufactured by the same process as the cap itself. As part of the Scout program, Langley Research Center has conducted thermal performance tests on the AVCO Corporation material. These tests have indicated a greater sensitivity to aerodynamic shear stresses than has been indicated in the AVCO Corporation test program. For this reason, an additional test program to be conducted by AVCO Corporation and Langley Research Center has been outlined and will be completed during the next quarter. The objective of this program is to give a clear indication whether or not nose cap material will be able to withstand the excessive shears encountered in the Scout reentry. These shear forces are twice those expected in the most severe Apollo heat shield design trajectory.

Mission Natural Environment

The best available information on the meteoroid environment, meteoroid penetration characteristics and solar proton flux is being prepared for incorporation into the North American Aviation, Inc. Statement of Work. The portions of the Statement of Work which excluded meteoroids and radiation from the crew safety and mission success reliability calculations will also be revised to include these environments. North American Aviation, Inc. is being asked to investigate the impact on spacecraft design of the proposed changes before the formal change is actually made.

It has not been possible to produce high velocity simulations of meteoroid impacts in the General Motors Corporation - Santa Barbara program. An investigation of all available high velocity impact facilities indicates that particle velocities greater than 30 to 40 thousand feet per second cannot be obtained with the accuracy and repeatability required in this simulation. As a result, the General Motors Corporation program must proceed on a test program with a more restricted velocity range than originally desired. It will be necessary to obtain enough experimental information in the lower velocity range with which to extrapolate to the velocity ranges of interest (90,000 feet per second).

Performance and Trajectories

During the past quarter, MSC and MSFC have undertaken extensive investigations of the trajectory characteristics of the Saturn V supercircular reentry tests 504 and 505. Present indications from this study are that there are conflicting trajectory requirements from the standpoint of booster qualification and spacecraft reentry demonstration. MSC and MSFC are preparing a joint report defining the available alternative trajectories and the advantages and disadvantages of each. This information will be used as a basis for identifying an acceptable compromise flight plan if one exists.

RELIABILITY

A quarterly reliability panel meeting was held in September 1963 to provide status on the Apollo program. Topics discussed include the following:

1. Reliability Assessment of Lunar Mission System and Spacecraft
2. Reliability Assessment of Deliverable End-Items
3. Summary of Significant Test Program Failures and Corrective Actions
4. Status of Approved and Preferred Parts Program
5. Status of Apollo Reliability Training and Motivation Program
6. Status of Major Subcontractos' Reliability Programs
7. Status of Weight - Reliability Studies
8. Status of In-Flight Maintenance Program for Meeting Reliability Objectives

MSC initiated several independent reliability assessments on both selected deliverable end-items and specific systems. Examples of these assessments were the Little Joe II QTV and the LES for AFM 011.

Command and Service Modules

North American Aviation, Inc.- The reliability apportionments for mission success and crew safety were modified for the LOR mission and alternate modes of operation in this reapportionment. State-of-the-art reliability estimates have been made based upon subsystem reliability estimates and a recommended list of "on-board spares".

Weight versus reliability studies have been initiated, but the initial analysis has not been completed. This study has significance in MSC decisions relative to "in-flight maintenance".

Reliability assessments have been made by the contractor on boilerplates 6, 12, 13, and mission essential GSE. Detail reliability assessments will be made on all deliverable items.

Subsystems that are considered to be primary reliability problem areas are the EPS, SM RCS, CM RCS, and the SPS.

Lunar Excursion Module

The Grumman Aircraft Engineering Corp. reliability program plan was reviewed by MSC and initially disapproved pending clarification of the stress-to-failure philosophy. Initial reliability predictions have been made by Grumman Aircraft Engineering Corp.; and, as a consequence, a reapportionment to lower level of assemblies has been initiated. A weight-reliability study for LEM has been initiated. Preliminary results indicate that the overall reliability improvement obtained from in-flight maintenance is not significant but does not preclude reliability improvements in significant areas.

The LEM reliability plan as submitted by Grumman Aircraft Engineering Corp. was disapproved by MSC. Due to the MSC's objection to their reliability analysis using "Weibull," Grumman Aircraft Engineering Corp. requested a meeting to discuss a new approach. At the meeting on September 10, 1963, Grumman Aircraft Engineering Corp. acknowledged that the Weibull approach could not be used to analyze data generated from "stress-to-failure" tests with adequate statistical confidence. The current plan of Grumman Aircraft Engineering Corp. is to have vendors conduct at least four "stress-to-failure" tests and supply the data to Grumman Aircraft Engineering Corp. Grumman Aircraft Engineering Corp. will then plot the data to determine trends. The ability of Grumman Aircraft Engineering Corp. to attach any significance to the trend line plotted was questioned. After considerable discussion, which included an alternate plan of data review presented by MSC, the meeting was adjourned with no resolutions except that Grumman Aircraft Engineering Corp. would consider the MSC proposal. It appears that a realistic approach to the reliability problem has not been formulated.

MSC and Grumman Aircraft Engineering Corp. personnel discussed the reliability requirements of Government furnished flight and ground instrumentation. Grumman Aircraft Engineering Corp. has expressed a need for NASA to provide reliability data on all GFE that they will be directed to use. Grumman Aircraft Engineering Corp. was requested to submit a letter outlining the specific data they considered essential.

SPACECRAFT-LAUNCH VEHICLE INTEGRATION

Spacecraft-launch vehicle integration includes not only the integration of the spacecraft to the launch vehicle but also the installation of the associated launch and flight control GSE. These activities are accomplished through the following MSC-MSFC-LOC coordination panels. Major accomplishments of the Mechanical Integration Panel, Flight Mechanics Panel, Electrical Integration Panel, Launch Operations Panel, and the Crew Safety Systems Panel are as follows:

Mechanical Integration Panel

It was agreed by MSC and MSFC that MSC will conduct comparative LES tower static deflection tests utilizing a boilerplate CM and an AFRM CM.

An agreement was reached between MSC and MSFC that the spacecraft supplied to MSFC for Saturn I dynamic test article will consist of inert launch escape system, boilerplate CM, AFRM SM, and AFRM Saturn I adapter. MSC-ASPO refers to this test article configuration as boilerplate 27 (Saturn I).

An agreement was reached between MSC and MSFC that the spacecraft supplied to MSFC for Saturn IB and Saturn V dynamic test article will consist of boilerplate 27 (Saturn I) with the Saturn I adapter replaced by a LEM test article (LTA no. 2) and an AFRM Saturn IB adapter. MSC refers to this test article configuration as boilerplate 27 (Saturn IB).

MSC and MSFC agreed that an interface control document will be prepared for each space vehicle.

It was agreed by MSC and MSFC that the boilerplate 26 SM, insert, and adapter would be transported horizontally aboard the "Pregnant Guppy" aircraft to MSFC.

MSC will provide a 15 in. diameter access hole with a gasketed cover in the bottom of the boilerplates 16 and 26 CM structure and heat shield symmetrically about the center line.

It was agreed between MSC and MSFC that MSC will provide mounting surfaces in the Saturn IB LEM adapter for MSFC electrical instrumentation on SA-201 through SA-203.

It was agreed between MSC and MSFC that MSFC would provide the master tooling pattern for Saturn IB adapter and Saturn V adapter to instrument unit bolt circle.

It was agreed between MSC and MSFC that MSFC would provide the master tooling pattern for Saturn IB adapter and Saturn V adapter to instrument unit bolt circle.

It has been established and reported by MSFC that spacecraft center of gravity location within six inches and 90 pounds can be tolerated by the launch vehicle.

Flight Mechanics Panel

MSC defined acceptable accuracies for Saturn I and IB earth orbital insertion as: velocity ±35 fps, flight path angle ±0.25°, altitude ±3,000 feet and yaw angle ±0.1°. These accuracies are for a three orbit mission only. Work is proceeding on insertion accuracy versus time required in orbit, up to a maximum of 14 days. Launch vehicle insertion accuracy is expected to be much better than the above requirements.

The maximum spacecraft requirements for S-IVB attitude control in earth orbit of all Saturn IB flights is 3 hours. A system capable of $4\frac{1}{2}$ hours of attitude control, which can be off-loaded to 3 hours on Saturn IB flights with the LEM with a payload penalty no greater than 700 pounds (orbital payload 31,800 pounds), is acceptable to MSC.

The following attitude control rates as defined by MSFC are acceptable for navigation sightings for S-IVB Saturn IB:

Saturn IB	Spacecraft and S-IVB	LEM and S-IVB
Roll	0.0615 deg/sec	0.0725 deg/sec
Pitch	0.0098 deg/sec	0.0181 deg/sec
Yaw	0.00995 deg/sec	0.01875 deg/sec

These attitude control rates are also considered acceptable by MSC for transposition and docking pending confirmation from docking simulations.

Subject to MSFC agreement to the payload penalty, MSC agrees to include a full Saturn V earth orbit timeline of $4\frac{1}{2}$ hours during a manned Saturn IB flight without the LEM.

If MSFC can design a $4\frac{1}{2}$ hour Saturn IB attitude control system within the payload penalty restriction, the S-IVB attitude control propellant tanks should be sized for the attitude maneuver requirements of Saturn V as defined in the Fifth Flight Mechanics Panel Meeting. This specifies one IMU alignment and four landmark sightings or six bright horizon sightings per orbit in each of three orbits.

The earliest allowable LES jettison times on Saturn IB and V should be based on the 1 psf dynamic pressure criteria.

A lateral accelerometer is not practical as a sensor for automatic aborts due to hard-over engine failure.

The membership and scope of two subpanels, a reference trajectory subpanel and a guidance and performance subpanel, were defined.

Electrical Integration Panel

The Saturn I instrumentation unit/Apollo electrical interface for SA-8 (boilerplate 26) and SA-9 (boilerplate 16) has been defined and published.

Additional definition has been accomplished relative to the MSC/MSFC Saturn-Apollo ground support electrical interfaces.

Selected MSFC specifications are being reviewed to determine applicability to MSC contractor effort. The establishment of a MSFC-MSC ground support equipment cable connector list has been initiated.

Launch Operations Panel

Panel structure and charter were reviewed. Operation under the MSC/MSFC charter of July 6, 1962 will continue. Sub-panel membership and operational procedures were reviewed and corrected.

By mutual agreement LOC, MSC, and MSFC have selected MSFC to maintain a repository for interface documentation. A procurement for operating the repository have been established.

Definition of the Apollo ingress-egress aims for the spacecraft has been accomplished.

Crew Safety System Panel

The Saturn I EDS design as proposed by MSFC has been reviewed by MSC. Agreement was reached between the two Centers on an EDS design which will satisfy the requirements of both Centers. Parameters to be monitored according to the agreement are:

a. Launch vehicle rate excessive

b. Thrust OK - each engine on each stage

c. Launch vehicle attitude error

d. Instrument unit power

e. Guidance and control status

f. Structural monitor

MSC and MSFC agreed to a Saturn I EDS flight qualification test program consisting of open loop tests on SA-9 and SA-8 and a closed loop test on SA-10. "Open loop" test was defined as requiring all launch vehicle sensors, logic, and wiring to the spacecraft interface. Those circuits for generating an actual abort or EDS engine cutoff will be open circuit. "Closed loop" test was defined as requiring all launch vehicle EDS hardware and associated spacecraft hardware with an abort and launch vehicle engine shutdown capability in the event of a launch vehicle malfunction.

Agreement has been reached between MSC and MSFC on the preliminary EDS specifications for the Saturn IB and Saturn V. MSFC will release these preliminary specifications to their contractors for implementation of necessary hardware design and installation. In general, the parameters to be monitored on the Saturn IB and Saturn V are very similar to those on the Saturn I. On Saturn IB, the EDS will monitor launch vehicle rate excessive, thrust OK - each engine on each stage, structural integrity, guidance and control status, angle of attack, and attitude error. The Saturn V EDS will monitor the same basic parameters as on Saturn IB with the addition of S-II and S-IVB fuel tank pressures.

The sub-panel established to study problems associated with failures occurring at or near lift-off has identified a number of possible means of obtaining the desired information. Plans have been made to implement these proposals on SA-5 to determine the adequacy of the data received for use in determining if an abort is required.

COMMAND AND SERVICE MODULE HARDWARE AND LAUNCH SCHEDULE

Flight Test Articles

Boilerplate 6.- During the last reporting period boilerplate 6 was moved into the WSMR complex. Build-up and checkout of the vehicle were delayed during the current reporting period due to difficulties experienced in the qualification of the Earth Landing System. Some redesign of the CM upper deck was required after the boilerplate 3 test failure at El Centro, California. The Space Ordnance pyrotechnics were replaced by the more proven Ordnance Associates pyrotechnics in the drogue and pilot parachute mortars. Essential modifications to the upper deck and parachute harness of boilerplate 6 have been accomplished and build-up is now in progress. Launch date is presently set for October 30, 1963.

Boilerplate 12.- Major changes are being incorporated in boilerplate 12 prior to scheduled mid-October - start of Downey checkout. NASA Design Engineering Inspection of boilerplate 12 was conducted September 10, 1963 and necessary modifications are scheduled to be completed before Downey checkout begins. Delivery to WSMR is scheduled for December 1, 1963, and launch for February 1, 1964. Hardware appears to be two to three weeks behind in meeting this schedule.

Little Joe II Launch Vehicle No. 1 qualification test flight was achieved during this period. The launch vehicle trajectory was within prescribed limits for the forthcoming boilerplate 12 high Q abort flight.

Boilerplate 13.- Boilerplate 13 is in the final assembly area. The launch escape tower, CM, SM, insert and adapter structures are completed and flight systems installation is progressing. Manufacturing will be completed October 20, 1963, with the DEI to be conducted October 10. Downey Test Preparation operations are scheduled for completion December 22, 1963, with air shipment of the spacecraft and GSE to AMR December 29 and 30, 1963. Launch is planned for March 15, 1964.

Boilerplate 15.- Boilerplate 15, second of launch and exit environment boilerplate spacecraft, is in the manufacturing final assembly area. Structural completion of the launch escape tower, CM, SM, insert and adapter was accomplished during this period. Installation of flight components is in progress. Field delivery is scheduled for March 1, 1964 with launch set for July 15, 1964.

Boilerplate 18.- The following documentation in support of the R and D Communications and Instrumentation Systems on boilerplate 18 has been transmitted to North American Aviation, Inc. during this period.

1. The Apollo R and D flight hardware list

2. The telemeter measurement requirements channel schedule

3. The instrumentation signal wiring diagram

4. The electrical power distribution diagram

5. The spacecraft ground support equipment interface diagram.

The following manufacturing has been accomplished on boilerplate 18.

1. The mating of the CM inner forward and inner aft structures has proceeded as planned, with mating to be completed on October 4, 1963.

2. The SM bulkhead has been completed and delivered to the SM assembly area.

<u>Boilerplate 22</u>.- During this reporting period, detailed fabrication was begun on boilerplate 22. Selection of an abort altitude has been narrowed to 60,000 ±10,000 feet. Decision has been made to incorporate approximately 20,000 lbs. of ballast in an upper ring of the dummy SM in order that the proper point on the Saturn C-I trajectory will be hit. Boilerplate 22 is scheduled into the assembly area on November 15, 1963, into final checkout on September 1, 1964, and for launch at WSMR on March 15, 1965.

<u>Boilerplate 23</u>.- The final installation and checkout of boilerplate 23 are now in progress at Downey, California. Work is also in progress for the installation of MCR 374. This MCR implements all approved changes resulting from RFC's on the boilerplate 12 DEI.

Lack of a detailed program for GSE to meet boilerplate 23 requirements remains a potential problem. GSE was not adequately provisioned for boilerplate 23, but a program was envisioned by North American Aviation, Inc. to use boilerplate 6 and boilerplate 23 GSE after required modification. However, because of slips in the boilerplate 12 schedule, it is uncertain that sufficient GSE will be available to meet requirements of boilerplate 12 overlap with boilerplate 23.

a. Planning is now in progress at North American Aviation, Inc. to shift GSE assets from boilerplates 6, and 12 and modify as necessary and also to initiate new fabrication in order to meet boilerplate 23 requirements.

b. Flight Technology group of the ASPO Corp. has reviewed mission requirements and states that should boilerplates 6 and 12 be successful, there will be no requirement to fly boilerplate 23.

Checkout is scheduled for completion by November 15, 1963. Boilerplate 23 will be placed in storage until January 2, 1964 and a formal DEI is tentatively scheduled for January 5, 1964. Movement to WSMR is set for February 16, 1964 with launch scheduled for March 13, 1964.

<u>Boilerplates 16 and 26</u>.- Boilerplates 16 and 26 have been assigned to the MSFC micrometeoroid experiments. Both of these structures are presently in manufacturing. At the end of this reporting period, boilerplate 16 command module was having the ablation insulation applied, was

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scheduled to move to final assembly prior to October 10, 1963 and scheduled out of manufacturing January 1, 1964. Boilerplate 26 continued in major subassembly and is scheduled into final assembly January 24, 1964 and out of manufacturing on April 15, 1964.

AFRM 002.- Manufacturing of AFRM 002 will begin in November 1963. Significant activity occurring during the preceding quarter has been the finalization of the measurement requirements and initial steps by MSC-IESD to provide required instrumentation systems.

Review of the mission plan for this airframe, with considerations involving present tower mode launch escape system, was accomplished. The results indicate the desirability of conducting this abort test at a higher altitude than the previously planned 20,000 feet in a flight regime where the tower flap, the second abort mode, will be experienced.

AFRM 010.- Manufacturing of AFRM 010 is scheduled to begin in April 1964. Significant activity occurring during the preceding quarter has been the finalization of measurement requirements and instrumentation systems requirements. A review of the configuration of this airframe has produced contractor-ASPO agreement that the CM RCS and the rate portion of the SCS should be added to make the configuration similar to that of AFRM 002. A SM similar to that of AFRM 002 has also been ordered for AFRM 010. These changes will make the airframe 010 configuration capable of performing any LES abort mission.

Ground Test Articles

Test fixture F-2.- Manufacturing of test fixture F-2 was completed during this reporting period. A DEI of the test fixture was held on August 24, 1963 at North American Aviation, Inc.'s Los Angeles Division. Twenty-five "Request for Change or Further Study" were written against the test article. Out of the twenty-five the DEI Board assigned 14 into Category I (implement immediately), 4 into Category II (study), 5 into Category III (rejected), and 2 into Category IV (not applicable).

Leak checks of the test fixture propellant lines have uncovered numerous leaks that have held up the shipment of the test fixture to the Propulsion Systems Development Facility, WSMR. It is anticipated that the leaks will be repaired and the fixture shipped to WSMR by mid-October 1964.

GSE will be the pacing item as to the start of testing with F-2. Late delivery of the GSE will slip the start of testing until March 1964.

Airframe 001.- Airframe 001 SM started buildup on the assembly jig on August 14, 1963. Manufacturing of the SM is on schedule when compared to Master Development Schedule No. 7. However, there could be a seven

[redacted]

to nine week slip due to late delivery of the instrumentation harness. The contractor has started to redesign the harness in order that an out of station installation may be accomplished. If this is accomplished, there should be little or no delay in the manufacturing of the SM. Based on the present schedule, the SM assembly should be completed by December 1, 1963, followed by final installation and checkout by the middle of March 1964. The SM will then undergo a two and a half month preparation at Downey, California prior to its shipment to PSDF-WSMR.

Airframe 006.- The CM and SM structural fabrication was begun during this reporting period. The CM structure is approximately 20 percent complete, and the SM structure is 17 percent complete. The C-1 adapter will begin fabrication December 20, 1963. The LES to be used on AFM 006 is the hardware previously used for the static firing, modified in accordance with current spacecraft design.

Airframe 008.- North American Aviation, Inc., made a presentation utilizing PACE carry-on equipment for spacecraft checkout and for transmission of R and D data to the ground station during the test runs. North American Aviation, Inc. is now considering using PACE carry-on for only spacecraft checkout, and using hardline to carry R and D measurement data to the ground station. It appears that the MDS-7 does not provide time at Downey for complete AFRM 008 check with PACE prior to shipment from the Apollo Test and Operations area. Schedule is now being reviewed to include complete checkout.

Boilerplate 14.- Fabrication of the structure for boilerplate 14 is in process. Subcontractors and vendor system components are being received on schedule. Several ECS and telecommunications system components are late but are not critical at present.

LEM FLIGHT TEST PROGRAM

LEM-1 will be used for evaluation of staging and separation dynamics under simulated lunar gravity and for determination of the operational characteristics of the ascent propulsion subsystem for a full duration unrestrained firing. A Little Joe II booster will be used for this flight.

LEM-2 will be used to evaluate staging and separation dynamics under emergency abort conditions and to evaluate plume effects on the descent stage landing gear. It will also be used to determine operational characteristics of the descent stage propulsion system for long duration firings. A Little Joe II booster will also be used for this flight.

[redacted]

LEM MANUFACTURING PROGRAM

The required revision of the LEM Manufacturing Plan was reviewed in detail with Grumman Aircraft Engineering Corp. on August 27, 28, and 29, 1963. Draft copies of a complete revision are due October 14, 1963. This revision is to include:

a. Management procedures and controls required to effectively "overlay" the projectized Grumman Aircraft Engineering Corporation LEM manufacturing management upon the Grumman Aircraft Engineering Corp. corporate manufacturing organization and facilities which are not projectized. Grumman Aircraft Engineering Corp. has decided to extend the LEM project manufacturing management one additional level, with a "LEM man" for each manufacturing department.

b. The production rate to be used as the base for the major manufacturing and assembly tooling is being revised by Grumman Aircraft Engineering Corp. from the originally proposed rate of two LEM's per month to the MSC recommended equivalent of 1.4 per month.

Manufacturing progress on mockups, test modules, and test articles, as of September 30, 1963 follows:

a. M-1, the cabin interior mockup was completed on schedule and NASA review accomplished September 17 and 18, 1963.

b. M-2, docking interface mockup, has not been started. A slight delay has been encountered pending better definition of the interface and the use of the mockup. The delay is not critical and is not expected to become controlling.

c. M-3, adapter interface mockup, and M-4, LEM exterior mockup, are both in progress and on schedule.

d. M-5, the complete LEM mockup, was started during this quarter.

e. TM-1 for visibility and crew mobility development support is 90 percent complete and on schedule.

f. The descent stage for TM-2, the thermal test article, is in progress. The ascent stage manufacturing effort has been stopped; however, since it has been determined that the experimentally fabricated ascent shell will not provide test results needed, a later prototype ascent shell will be substituted.

g. The antenna test model, TM-3, is in manufacture and nearing completion.

[redacted]

h. TM-4 is now scheduled to start in the 4th quarter of 1963.

i. The first $\frac{1}{6}$ scale model for landing gear development tests has been completed and is in use. The second model is being manufactured. A third and fourth model, for MSC and Langley Research Center use, are being added as a contract change.

j. RCS test stand structure is complete. The slosh rig test stand frame has been assembled and is ready for tank installation. Heavy weight propulsion test rigs are in manufacture. Four sets of the aluminum fuel and oxidizer tanks for the ascent stage have been manufactured.

QUALITY ASSURANCE

An Apollo Quarterly Quality Assurance Panel Meeting was held with specific emphasis given to program status. The three major Apollo contractors (North American Aviation, Inc., Grumman Aircraft Engineering Corp., and MIT) presented information on the following topics:

1. Design Review
2. Contractor Procedure Material Control Status
3. Contractor-Fabricated Article Control Status
4. Nonconforming Material Status
5. Quality Control Audits Status
6. Status of GFP Control
7. Status of Quality Control Laboratory Personnel and Process Certification

Command and Service Module

The North American Aviation, Inc. Apollo Quality Control Plan was reviewed and considered acceptable, with the exception that additional clarification is needed in the launch site operation. North American Aviation, Inc. has approved 8 of the 11 major sub-contractors' quality control plans. The remaining three subcontractor quality control plans are in the process of approval. At present, eleven NASA quality assurance representatives are in residence at major subcontractors. Subcontractor material review boards have been evaluated prior to approval. North American Aviation, Inc. has completed development of their plans for the subcontractors audit.

A summary of receiving inspection rejections show a decrease in percentage rejections.

Lunar Excursion Module

The design review participation of Grumman Aircraft Engineering Corp. Quality Control is limited to released drawings. This untimely review may result in costly changes to hardware.

Major subsystems contractors are covered by quality control representatives in residence. Of the nine major subcontractors, six are currently in residence.

The Grumman Aircraft Engineering Corp. Material Review Board (MRB) has been approved and is in effect. Quantities of MRB decisions were listed.

Personnel trained and certified for various processes including soldering are radiography to date is 139.

An investigation was initiated to ascertain that all environmental connectors on the Apollo spacecraft are protected from a failure of the type that occurred on MA-9.

Standard process specifications are being prepared for implementation into all Apollo contracts. Specifications have been prepared to cover GSE environmental criteria: splicing, crimping, identification and traceability and soldering.

Preliminary studies were conducted on the feasibility of establishing a MSC Electronic Data Processing Center for reliability and quality assurance data.

A program for personnel motivation was initiated at some contractor facilities. Planning is being done toward installing motivation programs at all Apollo contractor facilities. Program has been continued for keeping GIA informed.

The BU Weps Rep, Bethpage Inspection Plan was reviewed and approved subject to incorporation of minor changes.

Grumman Aircraft Engineering Corp.'s cost proposal on the soldering specification, MSFC-PROC-158B, has been reviewed and a position recommended for negotiation purposes.

MSC and Grumman Aircraft Engineering Corp. personnel discussed quality control requirements of Government furnished flight and ground instrumentation. Grumman Aircraft Engineering Corp. has expressed a need for NASA to provide qualification and quality assurance data on all GFE that they will be directed to use. Grumman Aircraft Engineering Corp. was requested to submit a letter outlining the specific data they consider essential.

SIMULATION AND TRAINING

ENGINEERING SIMULATION PROGRAM

The first issue of the North American Aviation, Inc. Engineering Simulation Program Plan has been issued. This plan describes the engineering simulation program through May, 1965, including simulation objectives, schedules, and facilities requirements. Evaluator E-1 began operation in June 1963. Evaluator E-2 will begin operation in October 1963. Evaluator E-5 will begin operation in February 1964. Simulator S-1 will begin operation in October 1964. Simulator S-2 will be in operation in December 1964.

Simulations of the present docking concept are being undertaken by North American Aviation, Inc. at the Columbus Division and will be completed during the next quarter. MSC is undertaking an independent simulation of this concept.

The Phase I Centrifuge Program Test Plan was published by North American Aviation, Inc. on September 26, 1963. The plan reflects the use of Evaluator I during the week of September 9, 1963 for training of the astronauts designated as the primary participants. The fixture for installation on the Johnsville Centrifuge was used for further training in the week of September 23, 1963 during integrated systems test. Data collection from dynamic runs is scheduled for October 28, 1963.

LEM Simulators

Vendor proposals for the LEM simulator visual display systems were received August 26, 1963. Subsequent requirements for specification changes prompted a resubmittal of the specification, and modified proposals are due October 11, 1963.

The hover and landing simulator at Grumman Aircraft Engineering Corp. finished operation in August 1963. The rendezvous simulation is currently in operation and is scheduled to run through October 1963. The abort simulation to be run at LTV has slipped from late October 1963 to early December 1963. MSC has developed a simulation for study of the extendible probe docking technique.

TRAINING AND TRAINING EQUIPMENT

Command and Service Modules

North American Aviation, Inc. has submitted preliminary design for systems trainers in response to MSC direction and CCA to the contract.

The Apollo part task trainer visual simulation system specification has been completed.

The result of the common computer study directed by MSC was a recommendation by North American Aviation, Inc. and Link Division, General Precision, Inc., the mission simulator subcontractor, that the DDP-24, built by Computer Control Company of Framingham, Mass., be used in both trainers. MSC concurred and procurement action for these units in in progress.

North American Aviation, Inc. and MSC conducted a design review on the Apollo mission simulator September 23, 24, and 25, 1963. Progress is satisfactory to date. The visual simulation systems remain the critical items in terms of schedule compliance.

Systems familiarization courses have been scheduled for the Mercury Project Office and Flight Crew Operations Division personnel.

Lunar Excursion Module

Grumman Aircraft Engineering Corp. has issued its specification for the visual simulation system for the LEM mission simulator. This action was proposed by Grumman Aircraft Engineering Corp. to allow use of the system in the engineering simulator with later use in the LEM mission simulator. Five companies have responded: Farrand Optical; American Car and Foundry; Electronics Division, Marquart - Pomona Division; Kollsman Instrument Company; and Link Division of General Precision Inc. Proposals are being evaluated.

OPERATIONS

SPACECRAFT CHECKOUT

Initial use of a PACE-SC ground station in support of checkout operations at the North American Aviation, Inc., Downey, Calif. facility is planned with boilerplate 14. Boilerplate 14 is a house spacecraft having all AFRM 009 and 011 flight systems. This use of PACE-SC with a boilerplate will allow confirmation of checkout methods and spacecraft to PACE-SC interfaces prior to the initiation of PACE-SC checkout of a flight article. Initiation of PACE-SC checkout with boilerplate 14 is planned for August 1964.

Similar Pace-SC checkout development is planned with Grumman Aircraft Engineering Corporation through the use of LTA-1, the Grumman "house spacecraft".

PACE-spacecraft operational functions, hardware interfaces, and test point requirements have been further defined. An Apollo vehicle measurements list for AFRM 011 which lists and defines airframe test points has been published.

Current planning of the LEM program indicates no requirements for PACE-SC at WSMR. This is premised on LTA-8 being utilized at MSC, Houston, Texas.

PREFLIGHT

Current planning for the development of PACE-SC checkout provides for initial use of a ground station at North American Aviation, Inc., in support of systems testing of an airframe in December 1964. Initial use of a ground station at Grumman Aircraft Engineering Corporation with LTA-1 is planned for February 1965.

GROUND TEST PROGRAM

COMMAND AND SERVICE MODULES

Airframe 006.- The instrumentation requirements are being established and will be released in accordance with MDS-7. At the present design and manufacturing schedules support MDS-7.

Boilerplate 14.- The Instrumentation Measurement List has been released at North American Aviation, Inc.

Boilerplate 27.- The spacecraft supplied to MSFC for Saturn I dynamic test article will consist of inert LES, boilerplate CM, airframe SM and airframe Saturn I adapter. MSC nomenclature for this article is boilerplate 27 (Saturn I).

North American Aviation, Inc. will conduct comparative LES tower static deflection tests utilizing a boilerplate CM and an airframe CM. The test results will be forwarded to MSFC four months prior to the first airframe CM flight to enable MSFC to modify the boilerplate 27 dynamic test data.

The spacecraft supplied to MSFC for Saturn IB and Saturn V dynamic test article will consist of boilerplate 27 (Saturn I) with the Saturn I adapter replaced by a LEM test article (LTA-2) and an airframe Saturn IB adapter. MSC nomenclature for this article is boilerplate 27 (Saturn IB).

Mockup 23.- Partial Apollo spacecraft for umbilical and CM access platform test at Launch Operations Center. Contract Change Authorization No. 88, Master Serial No. 150-147, was initiated to create the subject article. North American Aviation, Inc.'s preliminary design study was submitted September 26, 1963 on schedule and is being approved for fabrication and scheduled delivery to Launch Operations Center on or before April 1, 1964.

LUNAR EXCURSION MODULE

Efforts during the last quarter have been directed toward development and implementation of a firm LEM ground and flight test program. Planning, documentation, and documentation review methods and schedules have been further defined. Test philosophy and ground rules have been established in more detail. Test logic and feasibility, checkout philosophy and requirements, and facility and GSE requirements have been studied and are undergoing more detailed analysis. The use of test PERT networks was initiated and these networks have been developed and reviewed.

From these various studies, a LEM Ground and Flight Test Program was prepared for MSC Management Review.

As a result of MSC Management Review, a firm LEM Ground Test Program has been established. The program for the LEM Test Aritcles (LTA) is summarized on the following page.

Vehicle	Vehicle Use	Test Location
LTA-1	House spacecraft	Grumman Aircraft Engineering Corporation
LTA-2	Dynamic test article	MSFC
LTA-3	Structural tests	Grumman Aircraft Engineering Corporation
LTA-4	Vibration and house spacecraft	Grumman Aircraft Engineering Corporation
LTA-5	Propulsion qualification	WSMR
LTA-6	CSM/LEM integration	North Americian Aviation, Inc.
LTA-7	Manned LEM environmental vehicle	MSC
LTA-8	Manned CSM/LEM compatibility	MSC

LTA-1 will be used to establish that LEM subsystems are compatible and also to test modifications resulting from the ground and flight test programs. In addition, LTA-1 will be used to develop procedures and verify vehicle compatibility with GSE.

LTA-2 will be sent to MSFC for use in dynamic tests with the Saturn 1B and Saturn 5.

LTA-3 will be used to determine structural strength margins and failure modes for the LEM. It will also be used for modal tests, stage separation tests, and lunar landing tests.

LTA-4 will be used for vibration tests and for an early evaluation of the LEM system in Grumman Aircraft Engineering Corp.'s altitude facility. It will then be used as a house spacecraft to develop procedures and evaluate modifications to the LEM vehicle.

LTA-5 will be used as the propulsion qualification vehicle at WSMR. LTA-5 will also be used to evaluate the fire-in-the-hole associated with lunar launch and emergency abort conditions. The propulsion system will be operated with the stabilization and control and electrical power subsystems to evaluate their interactions.

LTA-6 will be tested at North American Aviation, Inc. to evalute the electrical and mechanical compatibility of the CSM/LEM and adapter. In addition, modal tests will be conducted on the CSM/LEM in the docked position.

LTA-7 will be tested at Houston, Texas in the Environmental Test Facility to evaluate the LEM in the thermal/vacuum environments of earth orbit, lunar orbit, and lunar landing. The vehicles will be manned for these tests when required.

LTA-8 will be mated with a CSM at the Houston, Texas environmental test facility to evaluate the docket LEM and CSM in the earth orbit, translunar and lunar orbit thermal/vacuum environments. The vehicles will be manned for these tests when required.

GROUND SUPPORT EQUIPMENT PROGRAM

COMMAND AND SERVICE MODULES

The STU Meeting (working group) was held at North American Aviation, Inc. and recommended the elimination of C14-607, the STU which controls and monitors the servicing equipment.

North American Aviation, Inc. has procured a Telemetry Ground Station Model No. C14-021 for use at Downey, Calif. However, this equipment, built by a subcontractor, does not meet the North American Aviation, Inc. procurement specification. North American Aviation, Inc. requested that NASA waiver EMI and soldering specifications. NASA refused the waivers, but did grant minor deviations in the soldering specification and in the EMI specification, but required a functional EMI dynamic test prior to acceptance.

A design review was held at North American Aviation, Inc. on the Spacecraft Instrumentation Test Equipment, C14-405, with emphasis on (a) self check, (b) use of Minute Man components, and (c) the control console. The results are that the self-check capability was reduced by approximately 40 percent.

MSC has placed a requirement that servicing equipment and CM and SM substitute units have local control. North American Aviation, Inc. had planned to control this equipment remotely using STU and/or PACE.

There was no standard for GSE power/signal connectors between GSE and the facilities/launch complex. This resulted in GSE being delivered to a facility and no mating receptacle being available. A working meeting was convened which developed a list of standard connectors to be used by the Apollo CSM. This list will be submitted as a recommended standard for joint MSFC, LOC and MSC use.

A complete list of GSE for use with boilerplate 14 was compiled and submitted for inclusion in the Boilerplate 14 Mission Directive.

Two documents, GSE Environmental Design Criteria, MSC-E-1 and GSE Environmental Implementation and Qualification, MSC-GSE-1, were reviewed in order to arrive at a common GSE Environmental Program for all contractors. These documents were finalized and transmitted to North American Aviation, Inc. for implementation.

The re-written GSE Provisioning Procedures were reviewed and comments were forwarded to the contracting officer on August 14, 1963.

Handling equipment requirements to support boilerplates 16 and 26 at MSFC were furnished to MSFC personnel. North American Aviation, Inc. has indicated all this equipment will be delivered in time to meet the MSFC need date.

North American Aviation, Inc. was advised that for the sequencing of Saturn V umbilical withdrawal apparatus and arm retracting devices, it is necessary to incorporate an electrical switch in each umbilical carrier to trigger withdrawal and retraction after the umbilical carrier has disconnected from the vehicle. On pre-launch released umbilicals, the switch will be used to confirm the proper operation and allow continuation of the launch count. North American Aviation, Inc. is to use this information in designing the umbilical disconnect sets for the airframe.

A list of GSE requirements and availability for handling and checkout of AFRM 002 and 010 was forwarded to North American Aviation, Inc. for review.

There have been 73 Figures "A" or Figures "B" received during this quarter. Of these, recommendations to the Apollo Procurement Office have been 30 approvals, 19 partial approvals, and one disapproval. There remain 23 Figures "A" or Figures "B" being processed by the GSE Branch of the CSM Engineering Office.

During this quarter, 86 GSE models were reviewed during two Official Design Reviews at North American Aviation, Inc. One GSE model was reviewed at AMR and two models were reviewed at North American Aviation, Inc. during special reviews. From the results of these reviews North American Aviation, Inc. received official NASA direction to proceed without change or to implement instructions prescribed on the North American

Aviation, Inc. "Request for Change or Further Study", Form 939-X. These forms were completed during the applicable Design Review Meeting.

Presently both NASA and North American Aviation, Inc. management are endeavoring to increase efficiency in several management and/or policy areas. These areas are:

a. Current GSE Schedules - Presently PERT network preparation is in process to improve GSE scheduling visibility.

b. GSE Acceptance Procedure - Currently "Interim Acceptance" is being used by NASA for GSE coming out of the manufacturing area.

In order to establish an acceptance procedure, North American Aviation, Inc. has been requested to prepare a detailed presentation at the next Apollo Systems Meeting, outlining recommendations for plans and procedures to use for acceptance GSE.

LUNAR EXCURSION MODULE

Definition of the LEM GSE program has progressed to approximately 75 percent complete and is expected to be completed during January 1964. Major considerations in definition of the GSE program are as follows:

a. Operational flow charts which show detail activity of the LEM vehicle from the end of manufacturing to launch are being generated to ascertain that all GSE requirements are being considered. Preliminary flow charts have been completed although the desired level of detail was not attained. Effort is continuing to develop the charts in a usable manner and completion is expected in January 1964.

b. Applicability of North American Aviation, Inc. CSM GSE for use on the LEM vehicle is being considered for each LEM GSE requirement. All North American Aviation, Inc. GSE supporting the Propulsion, RCS, EPS, ECS, and C and I subsystems has been reviewed for common use applicability; 37 items have been identified for potential common use and approximately 40 have been deferred pending further investigation. It is anticipated that about 75 items of LEM GSE will be common usage with the CSM GSE and it is further anticipated that all common use items will have been identified by December 1963.

c. Concurrent use, at field test sites, of common use GSE will be implemented to the extent possible. Procedures for implementation of concurrent use GSE are presently being established and it is expected that concurrent use GSE items will be defined by January 1964.

A PERT system which reports GSE on an item by item basis has been designed and the first report has been received. The first report includes approximately 35 GSE items. Additional reports are expected to include additional items although PERT will not be fully complete until the GSE program has been defined.

A LEM GSE plan has been prepared and submitted to Grumman Aircraft Engineering Corp. for comments. The plan contains guidelines for PERT, environmental design criteria, environmental testing, common and concurrent use GSE, traceability, and GSE documentation. Procedures for maintenance and failure mode analyses are being prepared for possible inclusion in the plan. It is expected that this plan will be officially released during November 1963.

FLIGHT PROGRAM

The Project Apollo Mission Schedule, as well as objectives and configurations are shown in figures 10 through 13.

The flight program now consists of the following:

PAD ABORT/LITTLE JOE FLIGHTS

a. One Little Joe II flight for launch vehicle qualification

b. One boilerplate and one airframe CSM for pad abort testing

c. One boilerplate and one airframe CM for abort at high dynamic pressures

d. One boilerplate CSM for high altitude abort test

e. Two Little Joe II launch vehicles and one boilerplate CSM are programed as backup/spares

SATURN I

a. Two boilerplate spacecraft* for launch exit environment determination

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*All spacecraft referenced in Saturn I phases are without the LEM.

b. One boilerplate CM with an airframe SM and adapter, for qualification of the SM and adapter structures and spacecraft-launch vehicle separation system

c. One airframe spacecraft for unmanned suborbital flight to qualify CSM systems and successful water recovery of the CM prior to first manned orbital flight

d. Three airframe spacecraft for manned orbital flight with water recovery.

In addition, two boilerplate spacecraft will be made available to MSFC for micrometeoroid experiments.

LAUNCH ENVIRONMENT - SATURN-I

The first launch exit environment test will be made with boilerplate 13. The spacecraft will be launched from AMR on SA-6 at a launch azimuth of 90°; the roll program will provide a flight azimuth of 150°. The escape tower will be jettisoned 10 seconds after S-IV ignition. The S-IV, the adapter, and the CSM will be placed in a 100-nautical-mile orbit. No recovery is planned. Objectives of this flight are as follows:

a. Determine the launch and exit environmental parameters to verify design criteria

b. Demonstrate physical compatibility of the launch vehicle and spacecraft under preflight and flight conditions

c. Demonstrate the structural characteristics of the LES under flight loading conditions

d. Demonstrate satisfactory launch escape tower separation.

A second launch exit environment test will be made with boilerplate 15. Objectives and flight plan are identical to boilerplate 13. Test results will provide a second data point for the Saturn I program.

STRUCTURAL QUALIFICATION

The mission for boilerplate 18 will be to qualify the spacecraft SM and adapter structures. The spacecraft launch vehicle will be launched from AMR on SA-10 and the roll program will provide a flight azimuth of 72°. The escape tower will be jettisoned approximately ten seconds after

S-IV ignition. The CSM will separate from the S-IV after S-IV burnout utilizing the aft facing SM RCS.

The RCS engines will be shut down approximately 20 seconds after separation. Both the S-IV and the CSM will be placed in a 100 nautical mile circular orbit. No recovery is planned.

Flight objectives are:

a. Demonstrate the structural integrity of the production adapter and SM structures for flight loads to be encountered on Saturn I flights

b. Evaluate the separation sequence and physical separation of the combined CSM from the launch vehicle.

c. Demonstrate the capability of the closed loop EDS to properly monitor launch vehicle performance.

SPACECRAFT QUALIFICATION - SATURN I*

Airframe 009 is to be an unmanned suborbital mission to qualify the spacecraft for manned orbital flight. The spacecraft will be launched from Complex 34 at a launch azimuth of 100° and the roll program will provide a flight azimuth of 105°. The escape tower will be jettisoned 10 seconds after S-IV ignition, and the spacecraft will separate from the S-IV at burnout, at an altitude of approximately 100 nm. Two firings of the SPS are planned prior to separation of the CM from the SM. A water recovery of the CM off Ascension Island is planned. Flight objectives are as follows:

a. Qualify the heat protection system at suborbital re-entry conditions.

b. Determine the satisfactory operation of the SM Propulsion System at Zero g for subsequent deorbit capability.

c. Determine operational characteristics of the CSM Systems.

d. Demonstrate satisfactory recovery operational techniques.

e. Demonstrate the compatibility of the production CSM with the Saturn I launch vehicle, including the EDS.

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*Spacecraft referenced under this heading are without the LEM.

Manufacturing sequence for AFRM-009 began on schedule with the start of subassembly of the CM structure on September 30, 1963. SM assembly of structure is scheduled to begin in January 1964 with 100 percent design review due November 15, 1963. (C)

SATURN IB

The Saturn IB phase of the Apollo program consists of the following:

a. Two boilerplate CM and LEM with spacecraft SM and adapters, for spacecraft launch exit environment determination.

b. One boilerplate CM with spacecraft SM, adapter, and LEM unmanned for structural qualification of spacecraft adapter and LEM, satisfactory separation of CSM from launch vehicle, and operation of closed loop EDS.

c. One spacecraft manned for evaluation of spacecraft and crew during maximum duration (14 day) earth orbit mission.

c. Three spacecraft for performing rendezvous, docking, transposition and midcourse correction maneuvers and manned operation of the LEM.

A study is being conducted to determine if there is a requirement for an additional unmanned earth orbital flight for spacecraft qualification prior to the first manned Saturn IB flight.

LAUNCH ENVIRONMENT - SATURN IB

The first launch environment test will be made with a boilerplate CSM. It will be launched on SA-201 at the AMR at a launch azimuth of 90° with a roll program providing a flight azimuth of 105°. The escape tower will be jettisoned 20 seconds after second stage ignition. The S-IVB and the spacecraft will be placed in a 105 nautical mile orbit. The S-IVB will stabilize the spacecraft for 3 orbits. No recovery is planned.

Objectives of the flight are:

a. Determine launch and exit environmental parameters to verify design criteria.

b. Demonstrate the capability of the open loop EDS to properly monitor launch vehicle performance.

A second launch exit environment test will be identical with the first with SA-202 being the launch vehicle.

SPACECRAFT QUALIFICATION - SATURN IB

A boilerplate CM with production SM, adapter and LEM will be used for an unmanned earth orbital mission to qualify the spacecraft prior to the first manned earth orbital Saturn IB flight.

The test spacecraft will be launched on SA-203 from the AMR at a launch azimuth of 105° with a roll program providing a flight azimuth of 72°. The S-IVB and spacecraft will be placed in a 105 nautical mile circular orbit with the S-IVB stabilizing the spacecraft for two orbits. The CSM will then separate from the S-IVB using the SM RCS. No recovery is planned.

Flight objectives are:

a. Demonstrate structural integrity of the production adapter and LEM structure for flight loads to be encountered on Saturn IB.

b. Demonstrate satisfactory separation of the CSM from the launch vehicle, adapter panel jettison, and operation of the LEM attach mechanism.

c. Demonstrate satisfactory operation of the closed loop EDS.

The requirement for an additional unmanned mission for spacecraft qualification is under study. Results of this study should be available by the time the next quarterly status report is published.

SATURN V PROGRAM

The Saturn V phase of the Apollo program consists of the following:

a. Two boilerplate spacecraft for launch exit environment determination.

b. Two production spacecraft, except for the LEM, for heat protection system qualification with water recovery.

c. One spacecraft unmanned for earth orbital spacecraft qualification.

d. One spacecraft for a manned earth orbital mission simulating a lunar mission.

e. Three spacecraft for manned lunar missions.

Specific objectives and flight plans for Saturn V missions are under study.

LITTLE JOE II LAUNCH VEHICLE DEVELOPMENT

Convair has completed manufacture and checkout of boilerplate 12 to support initial spacecraft flight. DEI is planned for October 1963. The vehicle will be placed in storage until required for spacecraft flight. The manufacture of the airframe and fins of the third and fourth vehicles has been completed. Installation of electrical and motor ignition circuits is in work on schedule. The first vehicle with the control system, vehicle no. 5 for boilerplate 22 flight, is nearly complete in the final assembly fixture. Manufacture of the thrust bulkhead and components for the sixth and last vehicle is in progress.

The launcher at WSMR sustained no significant damage from QTV flight and refurbishing has been completed. Final assembly and checkout of the spare launcher at San Diego, Calif. have been completed. Spare launcher will remain at San Diego, Calif. until required.

The design of the control system has been completed and ground qualification tests have begun. A pitch programer has been added to the autopilot for greater match of spacecraft test conditions.

The initial contract has been completed with Aerojet for rocket motors and canted nozzle development. Four Algol flight motors have been delivered to WSMR. The third and last Algol motor static firing to develop and qualify the canted nozzle was successfully conducted in August 1963. A contract will be negotiated with Aerojet for additional motors for vehicles no. 5 and no. 6 when spacecraft test requirements are known. A contract has been negotiated with Thiokol Chemical Corp. for pyrogen head type igniter with 1 amp 1 watt no-fire squib for use with recruit motors on future flight.

FACILITIES

COMMAND AND SERVICE MODULES

The status of the uncompleted industrial facilities at Downey, California, is as follows:

Data Ground Station Construction	15 percent complete
Building Six Modifications Construction	75 percent complete
Systems Integration and Checkout Construction	53 percent complete
Space Systems Development Facility	
Main Building Construction	9 percent complete
ECS Construction	93 percent complete
RCS Construction	87 percent complete
Parking Lot - Part II (Deferred until Building construction is complete)	

Formal facilities contracts were awarded to AVCO Corp. and Pratt and Whitney Aircraft.

LEM-WSMR

Plans for the LEM-WSMR facilities are proceeding approximately on schedule. However, a potential problem has developed because of continued delay in availability of FY-64 C of F funds needed for procurement of long lead time items. Early Congressional action on the NASA Budget or establishment of deviations in the Corps of Engineers procurement policies will be necessary to avoid serious delay in test stand completion.

GRUMMAN AIRCRAFT ENGINEERING CORPORATION PLAN

The September 15, 1963 revision of the Grumman Aircraft Engineering Corp. facilities plan was received September 30, 1963. Utilization of manufacturing facilities will be covered in the revised manufacturing plan due October 14, 1963. Tentative utilization of MSC and AMR facilities is reported, but resolution of test requirements and facility plans is still in progress.

PROGRAM EVALUATION AND REVIEW TECHNIQUE (PERT)

Grumman Aircraft Engineering Corporation completed 11 of 12 LEM subsystem networks. Three of these have yet to be reviewed by MSC engineers. GSE networks will cover individual requirements or pieces of equipment and only about half of these have been submitted. Preliminary networks have been prepared for final assembly and acceptance. Networks on ground tests and flight test program have been prepared by Grumman Aircraft Engineering Corp. and will be reviewed by the Project Office during the next quarter. Structures subsystem network requires major rework. It is planned that interfaces will be identified and the entire Grumman Aircraft Engineering Corp. PERT system integrated internally by December 1963.

The North American Aviation, Inc., PERT system is undergoing a major review and realignment to reflect results of the recent schedule review. A joint Contractor-MSC PERT network review and rework is scheduled for completion in October 1963. Contractor and MSC program control and engineering personnel have been participating in this major rework of PERT networks for all systems.

PUBLICATIONS - CSM (NAA - CONTRACT NAS 9-150)

Document No.	Title	Date
SID 63-472	Pretest Report for Tests of Apollo FD-S Free Oscillation Dynamic Stability Model to Determine Strake Efficiency in the 11x11' Test Section of Ames Unitary Plan Wind Tunnel	June 1963
SID 63-21-6	Monthly Quality Status Report	June 10, 1963
SID 62-300-14	Apollo Monthly Progress Report	July 1, 1963
SID 62-435	Apollo Spacecraft Familiarization	July 1, 1963
SID 62-109	Apollo Test Plan, Vol. 1-5	June 30, 1963
SID 62-417	GSE Planning and Requirements	July 1, 1963
SID 63-214	Apollo Spacecraft Description Manual High Dynamic Pressure Abort	May 15, 1963
SID 63-44	Apollo Wind Tunnel Model Nomenclature	July 1963
SID 63-448-1	Data Report for Ames UPWT Tests of Apollo 0.105 Scale FS-2 Static Force Model at MACH 0.5 to 3.4 to Evaluate Aerodynamic Strakes Attached to the C/M (5th Series)	July 1963
SID 63-448-2	Appendix C to above report	July 1963
SID 62-170-5	Apollo Wind Tunnel Program Report	July 1963
SID 63-754	Data Report for Wind Tunnel Tests of Apollo Launch Escape Vehicle Jet Effects Model (FSF-1) in the Langley Research Center 16' Transonic Tunnel	July 1963
SID 63-21-7	Monthly Quality Status Report	July 10, 1963
SID 63-317	Structural Analysis of the 0.050 and 0.059 Scale Apollo Dynamic Stability Models	July 1963
SID 62-702	Apollo Maintenance Concept	July 25, 1963

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PUBLICATIONS - CSM (NAA - CONTRACT NAS 9-150)

Document No.	Title	Date
SID 63-616	Data Report for Tests of Apollo Dynamic Stability Model (FD-3) to Determine C/M Stability and Launch Escape Vehicle Flow Separator Effects in the MACH Range from 1.5 to 10.0	July 1963
SID 62-300-15	Monthly Progress Report	August 1, 1963
SID 63-902	Data Report for Apollo Model FS-3 Wind Tunnel Tests in Tunnels A and C of the Von Karman Gas Dynamics Facility	July 1963
SID 62-417	Ground Support Equipment Planning and Requirements	August 1, 1963
SID 63-746	Final Report on Apollo Plasma Reentry Studies	July 5, 1963
SID 62-435	Apollo Spacecraft Familiarization Manual	June 1, 1963
SID 63-1027	Pretest Report for Static and Transient Pressure Tests of the 0.055 Scale Apollo PSTL-2 Model in the Ames Research Center 9X7 and 11X11' wind tunnels	August 1963
SID 63-911	Structural Analysis of the 0.055 Scale Apollo Transient Pressure Model (PSTL-2)	August 19, 1963
SID 62-822-5	Apollo Monthly Failure Summary	August 10, 1963
SID 62-1452	Apollo S/C GOSS Communications Circuit Margins	August 2, 1963
SID 63-955	PACE Breadboard Phase D Test Format	August 7, 1963
SID 63-274	Data Report for Wind Tunnel Tests of a 0.10 Scale Apollo Model (FSC-1) to Determine Effect of C/M and Several Parachute Parameters on Drogue Parachute Stability	July 1963

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PUBLICATIONS - CSM (NAA - CONTRACT NAS 9-150)

Document No.	Title	Date
SID 63-21-8	Monthly Quality Status Report Apollo S/C	August 10, 1963
SID 63-881	GOSS Interface Report	August 1, 1963
SID 62-300-16	Monthly Progress Report	September 1, 1963
SID 62-557-6	Quarterly Reliability Status Report	July 31, 1963
SID 63-685	Experimental Heat Transfer Distributions over Launch and Entry Configurations of 0.045 Scale Apollo Models H-2, HL-1, and HL-1B at MACH Nos. 2.5 and 3.71	August 3, 1963
SID 63-1196	Apollo Description Manual for BP 13	August 23, 1963
SID 63-279	Data Report for Low Speed Wind Tunnel Tests of 0.10 Scale Apollo Model (FDC-1) to Determine Dynamic Stability Characteristics of the C/M and Drogue Parachute Combination	August 1963
SID 63-21-9	Monthly Quality Status Report	September 1963

[redacted]

LEM - GAEC - CONTRACT NAS 9-1100

Publications

LSP 390-301	Lunar Excursion Module Tank Assembly, Storage and Supply, Cryogenic Hydrogen and Oxygen, Electrical Power Subsystem, Design Control Specification for	August 12
LVR 390-501	Tank Assembly, Storage and Supply, Cryogenic Hydrogen and Oxygen, Electrical Power Subsystem Vendor Requirements for	
LTP 390-1	LEM Electrical Power Subsystem Preliminary Test Plan for the Development and Qualification of the Power Generation Section	
LSP 390-3	Battery, Spacecraft Storage, Silver Oxide-Zinc, Design Control Specification for	
LVR 390-3	Battery, Spacecraft Storage, Silver Oxide-Zinc, Vendor Requirements for	
LPL 540-1	Mission Plan	
LSP 440-41001	External Visual Display Design Control Specification	
LSP 380-1	Communication Subsystem, Design Control Specification for	August 8
LSP 360-2	Pulse Code Modulation and Timing Equipment, Design Control Specification for	August 5
LVR 360-2	Pulse Code Modulation and Timing Equipment, Vendor Requirement for	August 6
LVR 380-1	Communications Subsystem, Vendor Requirement for	August 8
LED 470-4	LTA 8 and LTA 9 Preliminary Design Summary Report	July 15

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LEM - GAEC - CONTRACT NAS 9-1100

Publications

LVR 360-4	Data Storage Equipment Vendor Requirement for	August 21
LSP 360-4	Data Storage Equipment Design Control Specification for	August 12
LED 380-2	Requirements of the Low Light Level LEM TV Camera	August 23
LSP 330-2A	Design Control Specification for Lunar Excursion Module Environmental Control Subsystem Sections 1, 2, 3, and 4	August 8
LTP 560-2.6-600	Test Plan for Equipment Heat Transfer to Cold Plates at High Vacuum	July 30

[redacted]

Supplement to ASPO-LEM

Publications

LTP 520-1	Preliminary Hydervelocity Impact Testing of Glass Material	September 4
LED 520-1A	Design Criteria and Environments LEM	August 15
LDL 610-1	Feasibility Study and Detailed Test Plans for LEM 1 and 2	September 6
LPL 600-1A	Test Plan for LEM Project Apollo Vol I	August 7
LVR 280-4	Propellant Tank Assembly Descent Stage Vendor Requirement	August 7
LPL 2-1	Facilities Plan	
LED 520-2	Preliminary Analysis of Lunar Surface Models	
LPL 550-1	Reliability Plan	
LMA 11-1	LEM Instruction Manual for Numbering and Processing of Correspondence, Drawing and Other Documentation	
LSP 280-4	Propellant Tank Assembly, Descent Stage, Design Control Specification for	August 7
LED 520-5	Proposed Vibration Design and Test Procedure for the LEM	July 30

PUBLICATIONS - GUIDANCE AND CONTROL (MIT - CONTRACT NAS 9-153)

Document No.	Title	Date
E-1333	Cloud Cover Data for Landmark Studies	March 1963
E-1378	Monthly Technical Progress Report	May 1963
E-1359	Flight Test Plan Apollo G and N Systems	May 31, 1963
E-1142	Weight and Balance Report	June 1963
R-415	Apollo Reentry Guidance	July 1963
E-1313	Thermal Grounding Analysis for Circuit Structures	April 1963
E-1363	Status of Apollo Flight Safety Design and Development	June 1963
R-408	Design Concepts of the Apollo Guidance Computer	June 1963
E-1142	Systems Status Report	July 15, 1963
E-1389	Quarterly Technical Progress Report	June 1963
E-1374	Propagation of Altitude and Altitude Rate Errors during Suborbital Flight	June 1963
R-417	A Unified Explicit Technique for Performing Orbital Insertion, Soft Landing and Rendezvous with a Throttleable Rocket - Propelled Space Vehicle	August 1963
R-387	Orbital Element Variations for a Body in Orbit around the Moon	July 1963
E-1385	Visibility Data and the Use of Optical Aids	July 1963
R-389	Requirements of and Index to Design Evaluation, Qualification, and Reliability Test Program for Apollo N and G System	July 1963
E-1142	Systems Status Report	August 1963

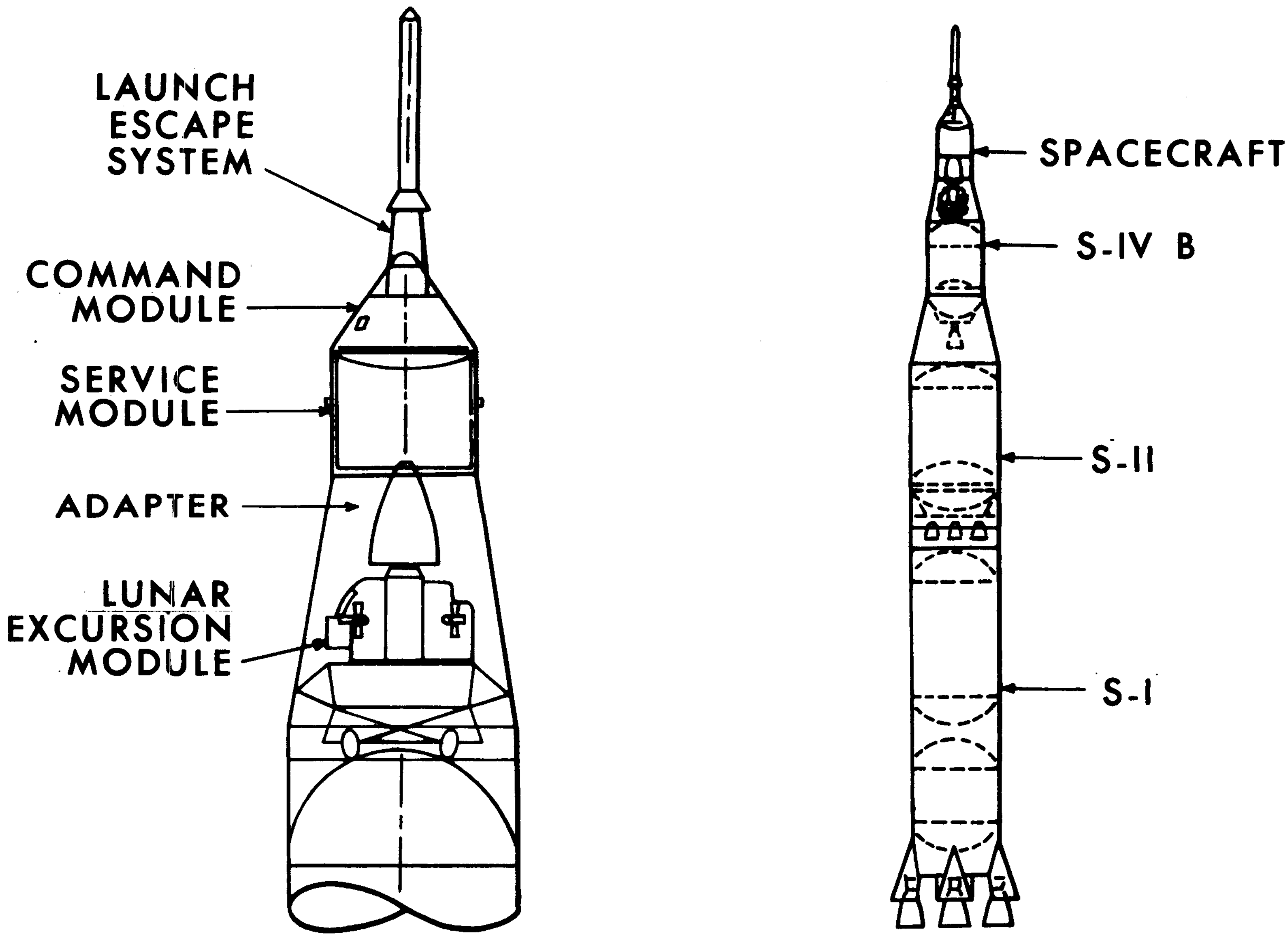

Figure 1.- Apollo Space Vehicle Configuration

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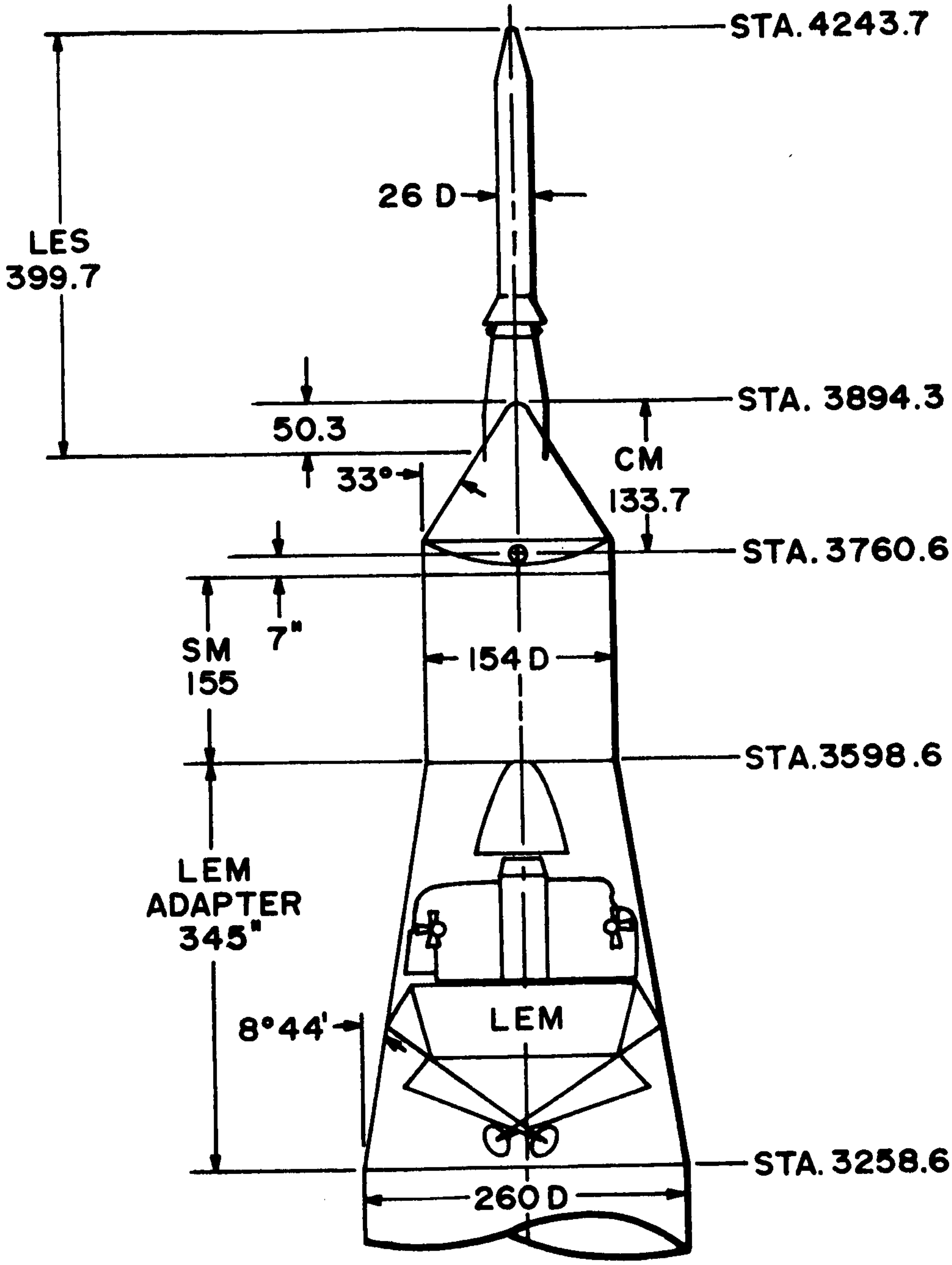

Figure 2.-Apollo Spacecraft Configuration

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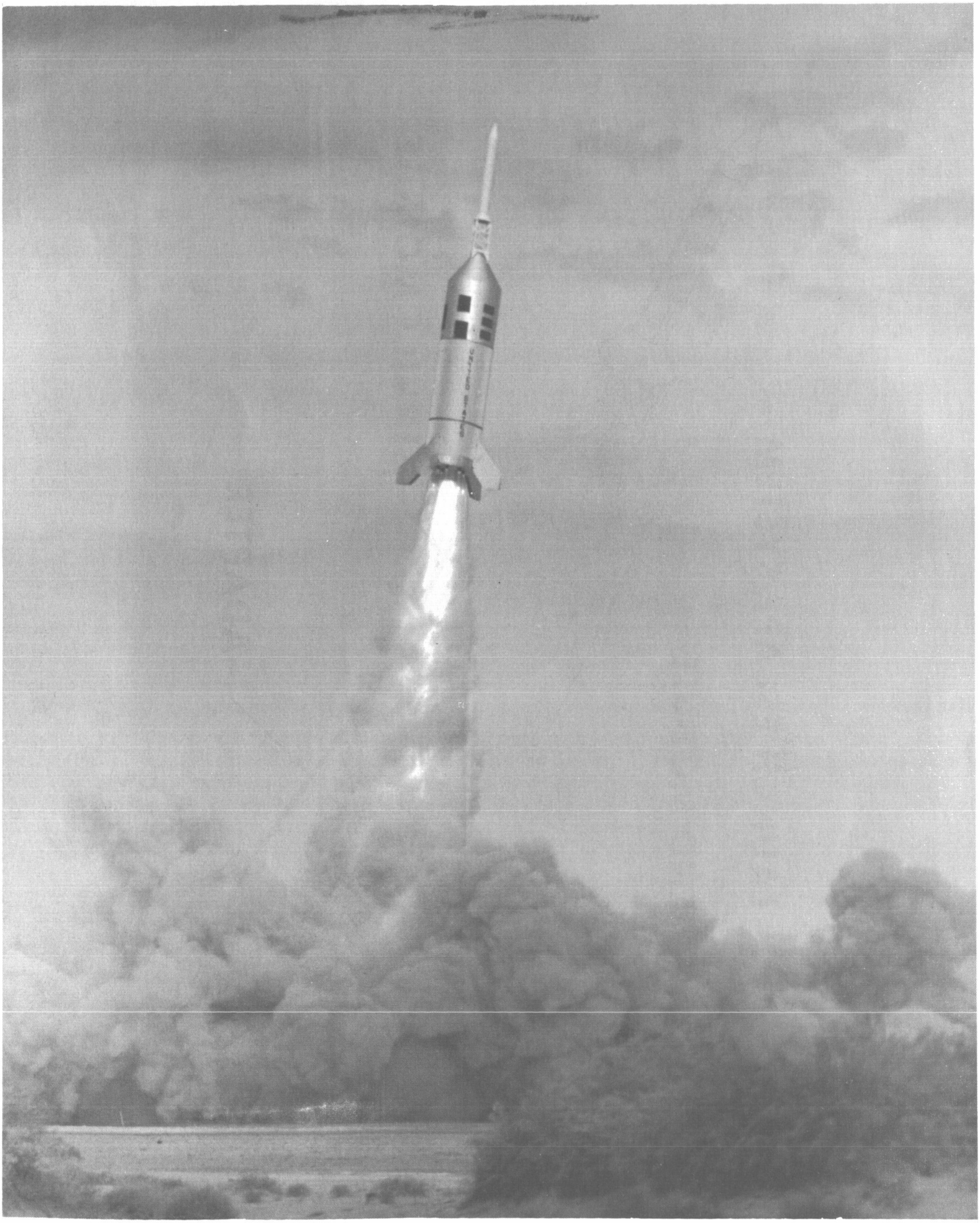

Figure 3.-Little Joe II Launch Vehicle

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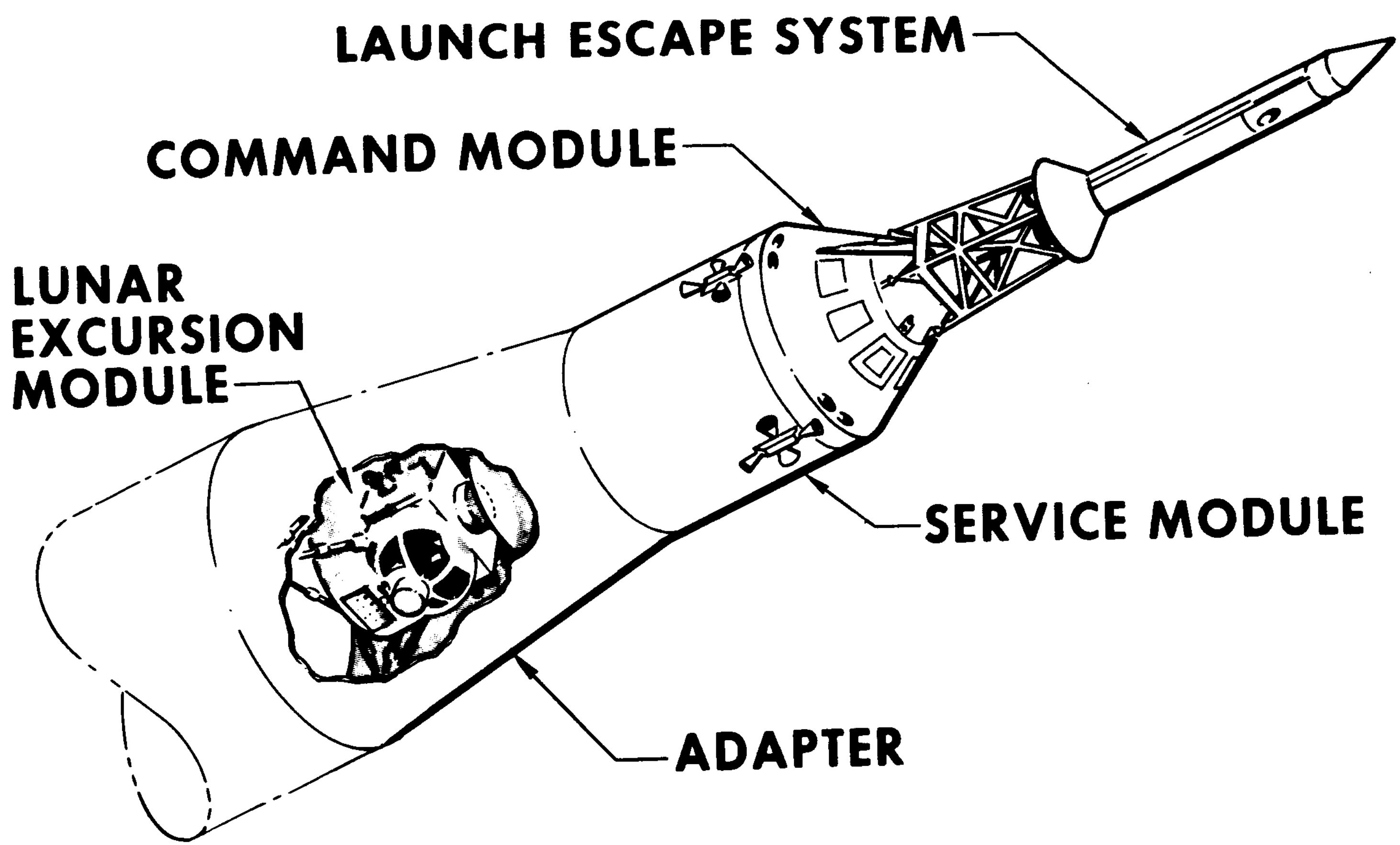

Figure 4.—Apollo Spacecraft

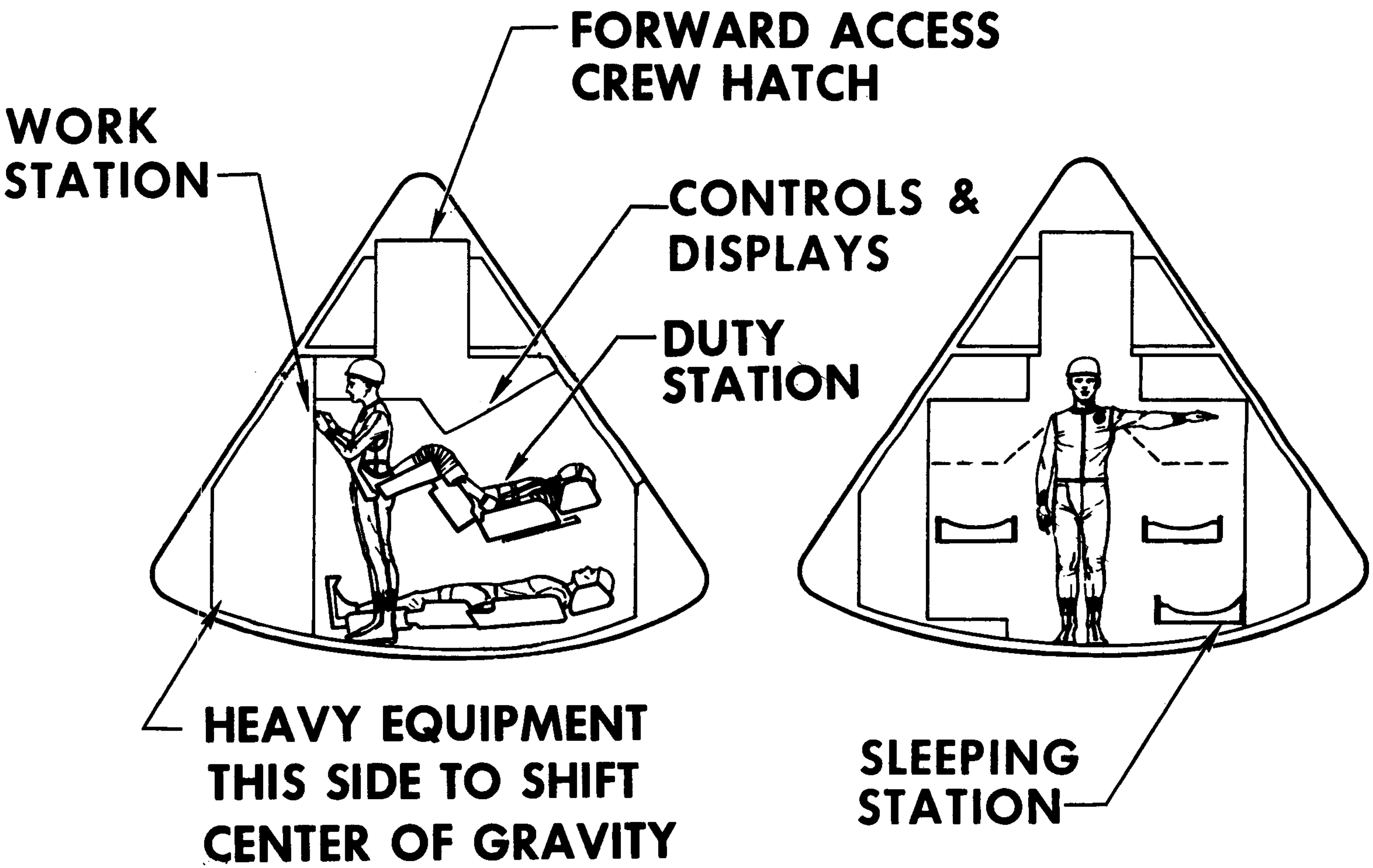

Figure 5.- Command Module

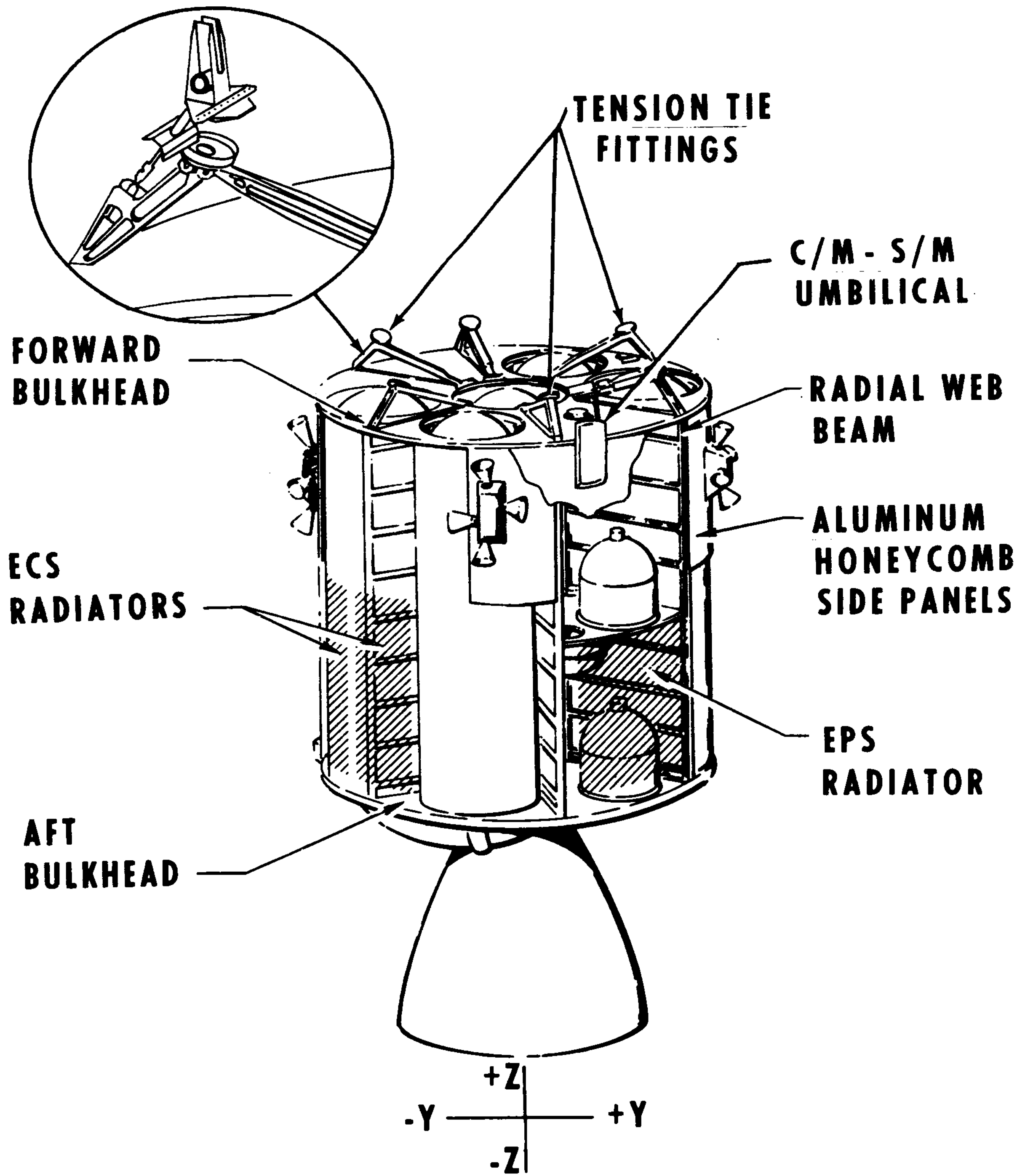

Figure 6.—Service Module

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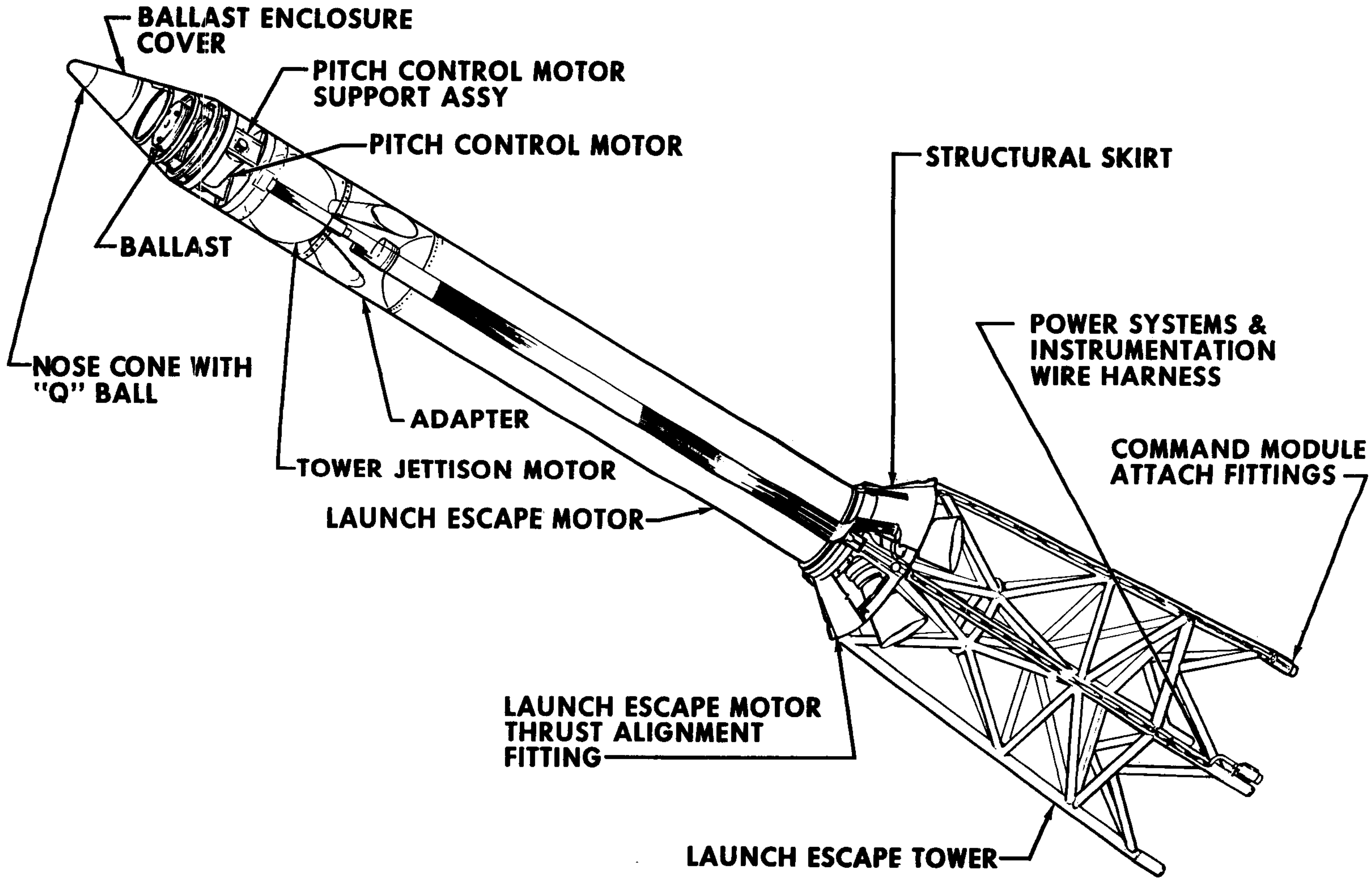

Figure 7.- Launch Escape System

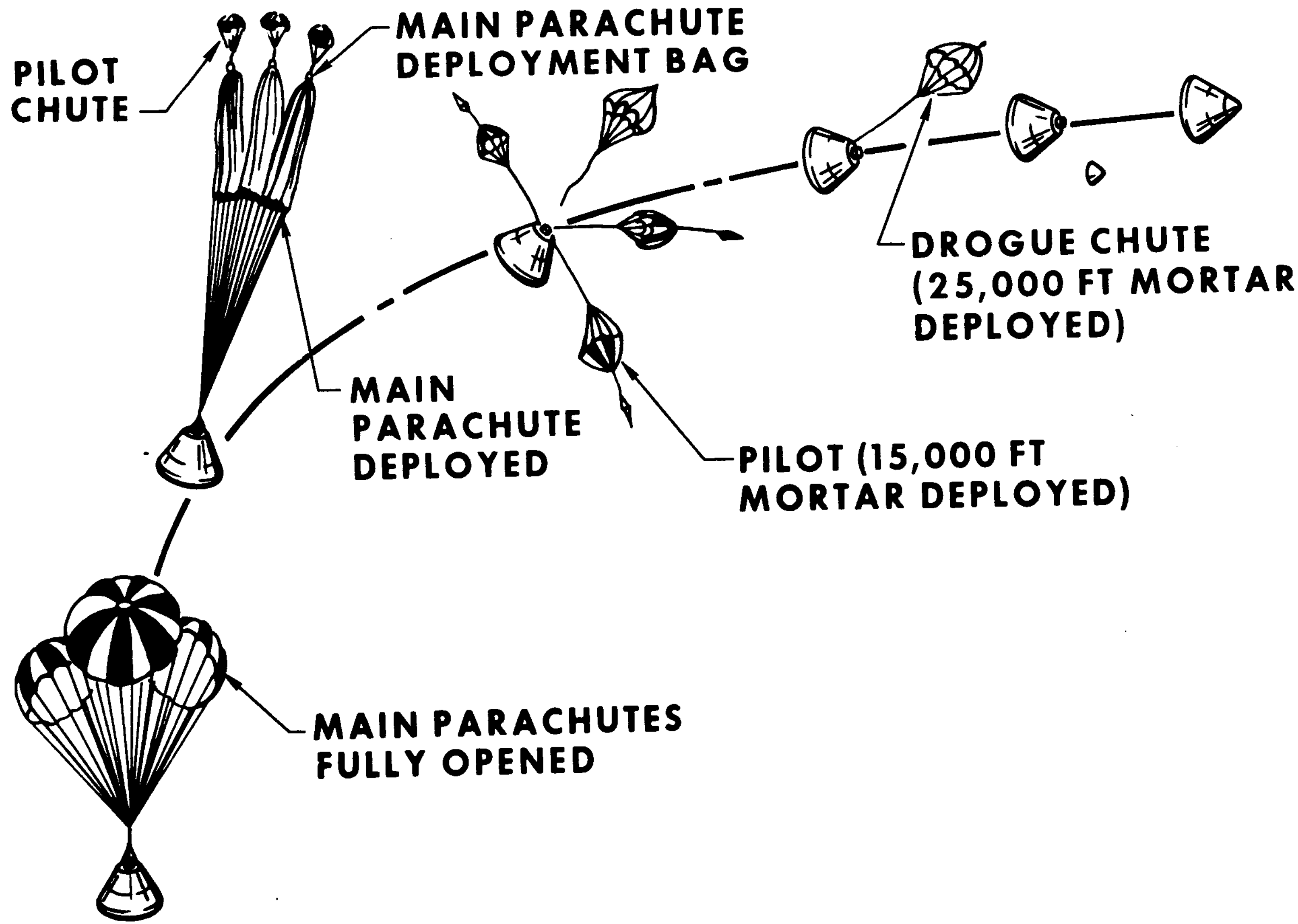

Figure 8.—Earth Landing System

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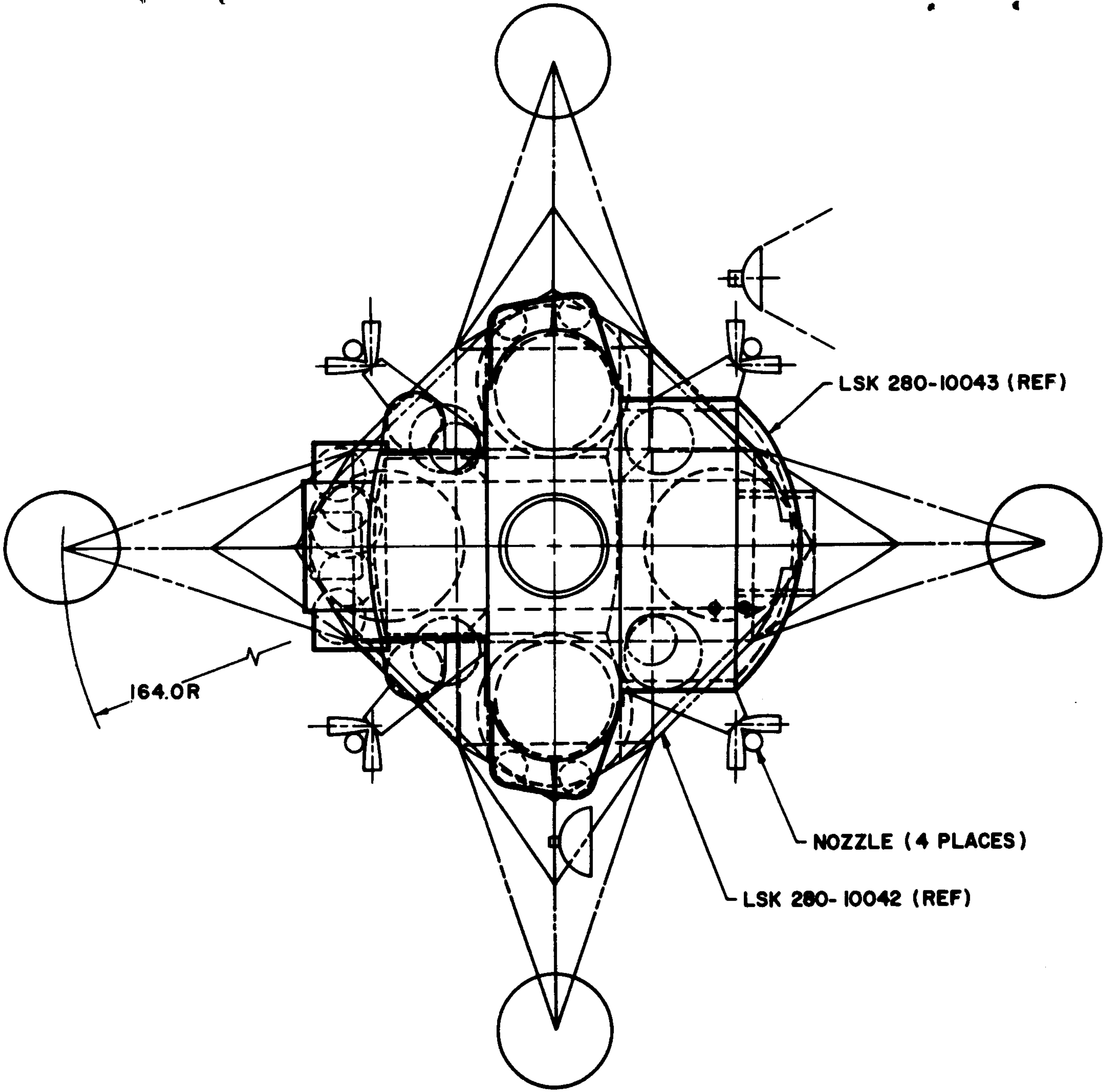

Figure 9.—Lunar Excursion Module Configuration

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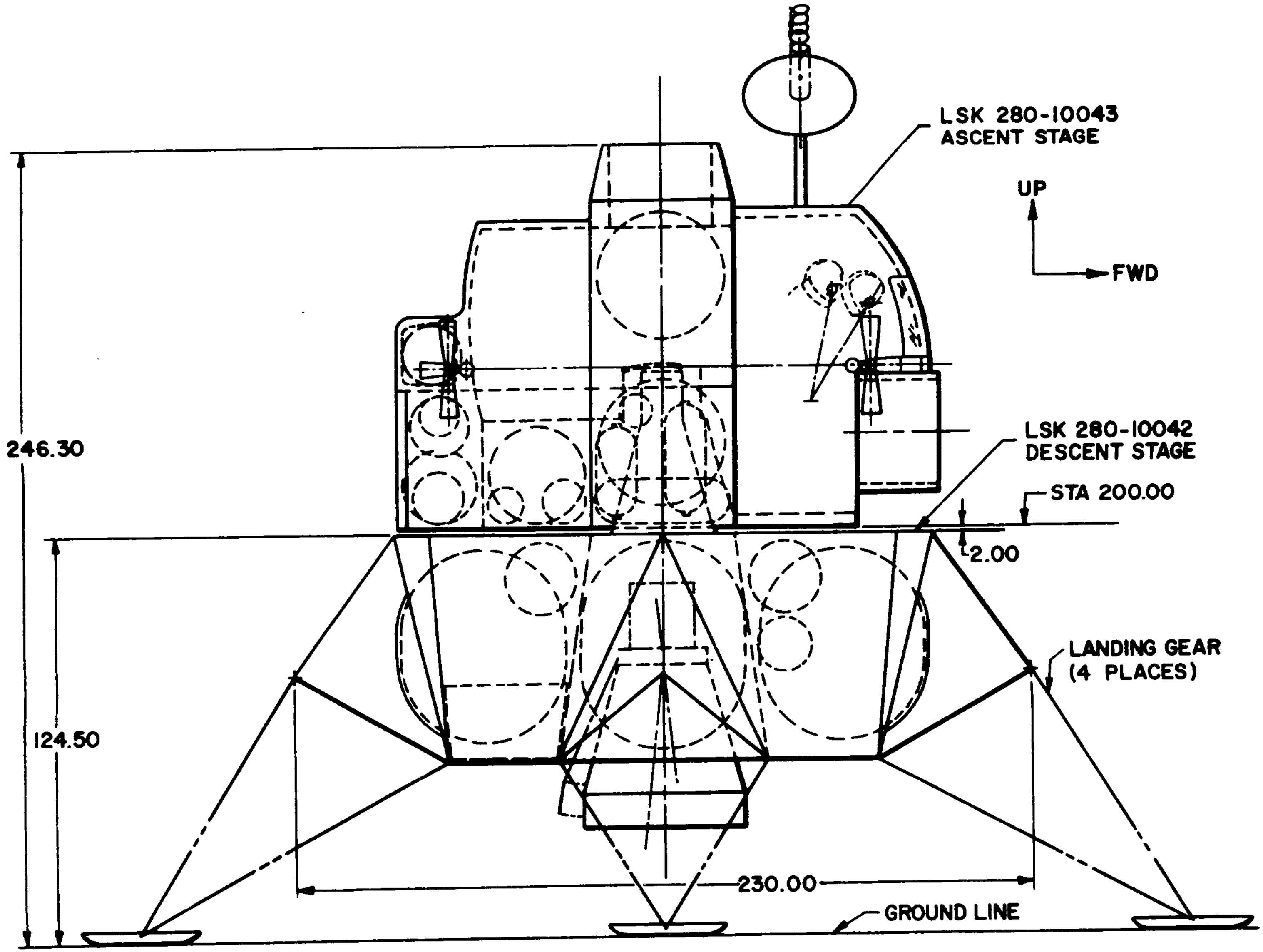

Figure 9.--Lunar Excursion Module Configuration (Concluded)

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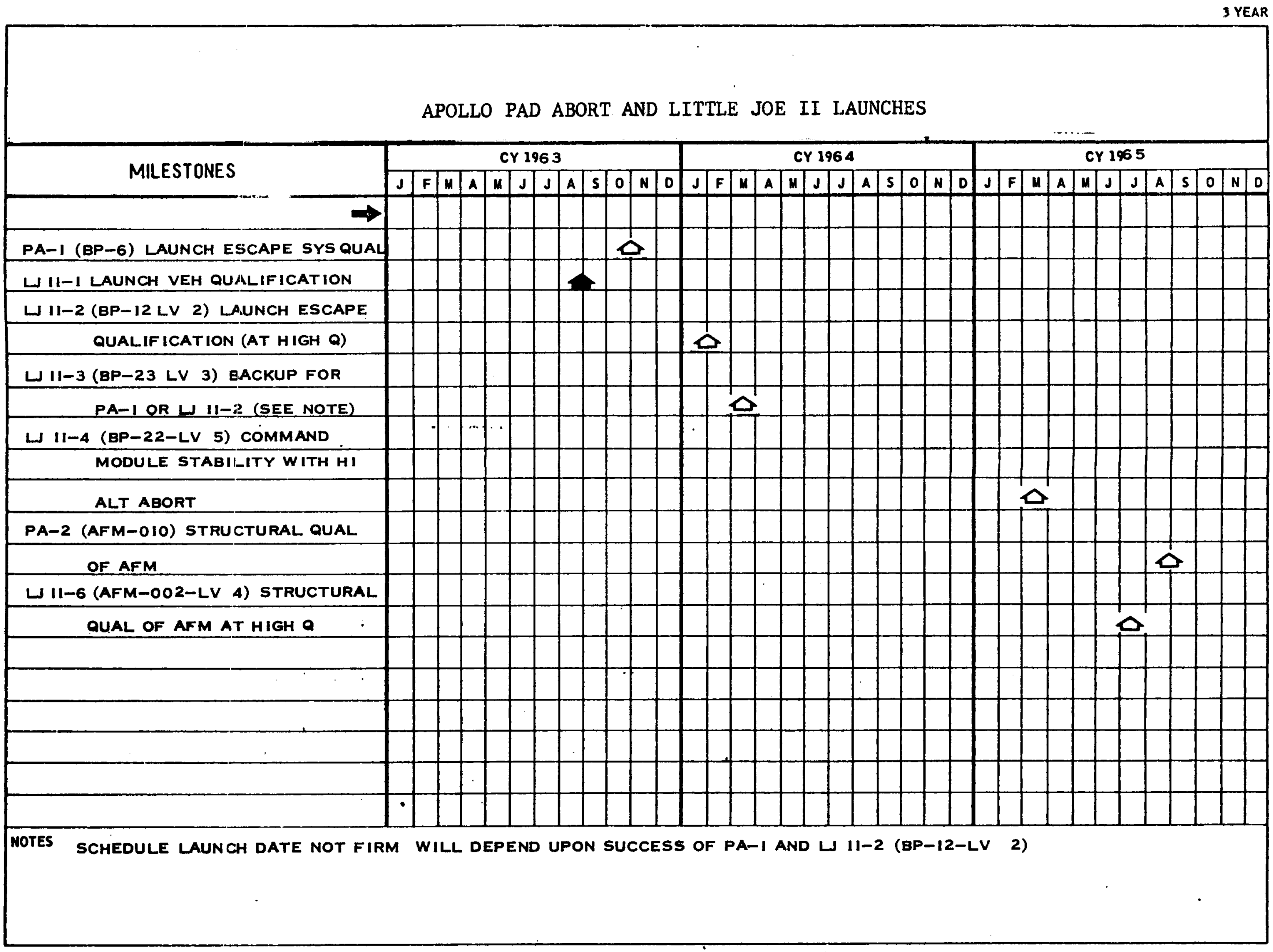

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Figure 10.– Apollo Pad Abort and Little Joe II Launches (as of Sept. 30, 1963)

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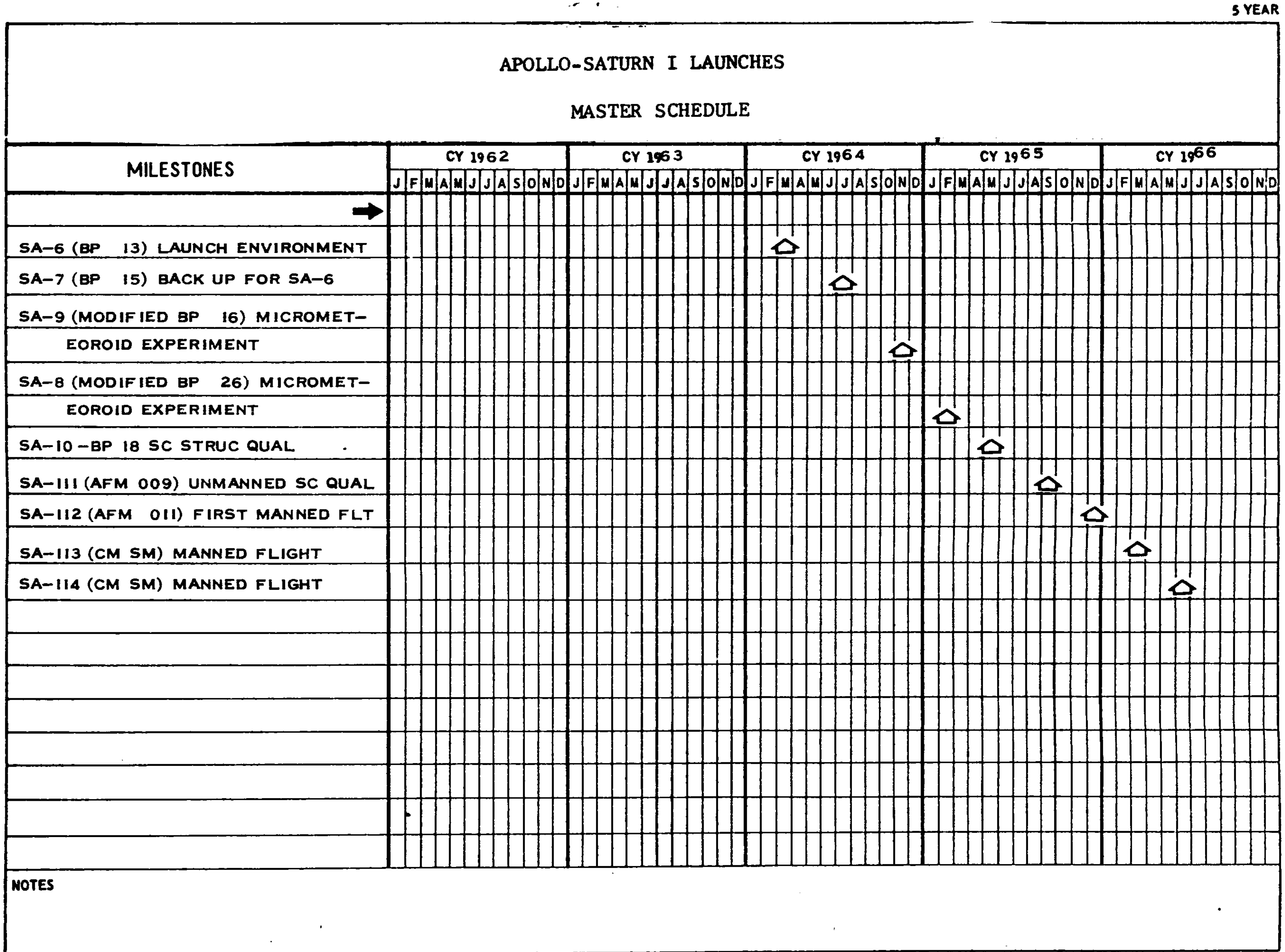

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Figure 11.- Apollo Saturn I Launches (as of Sept. 30, 1963)

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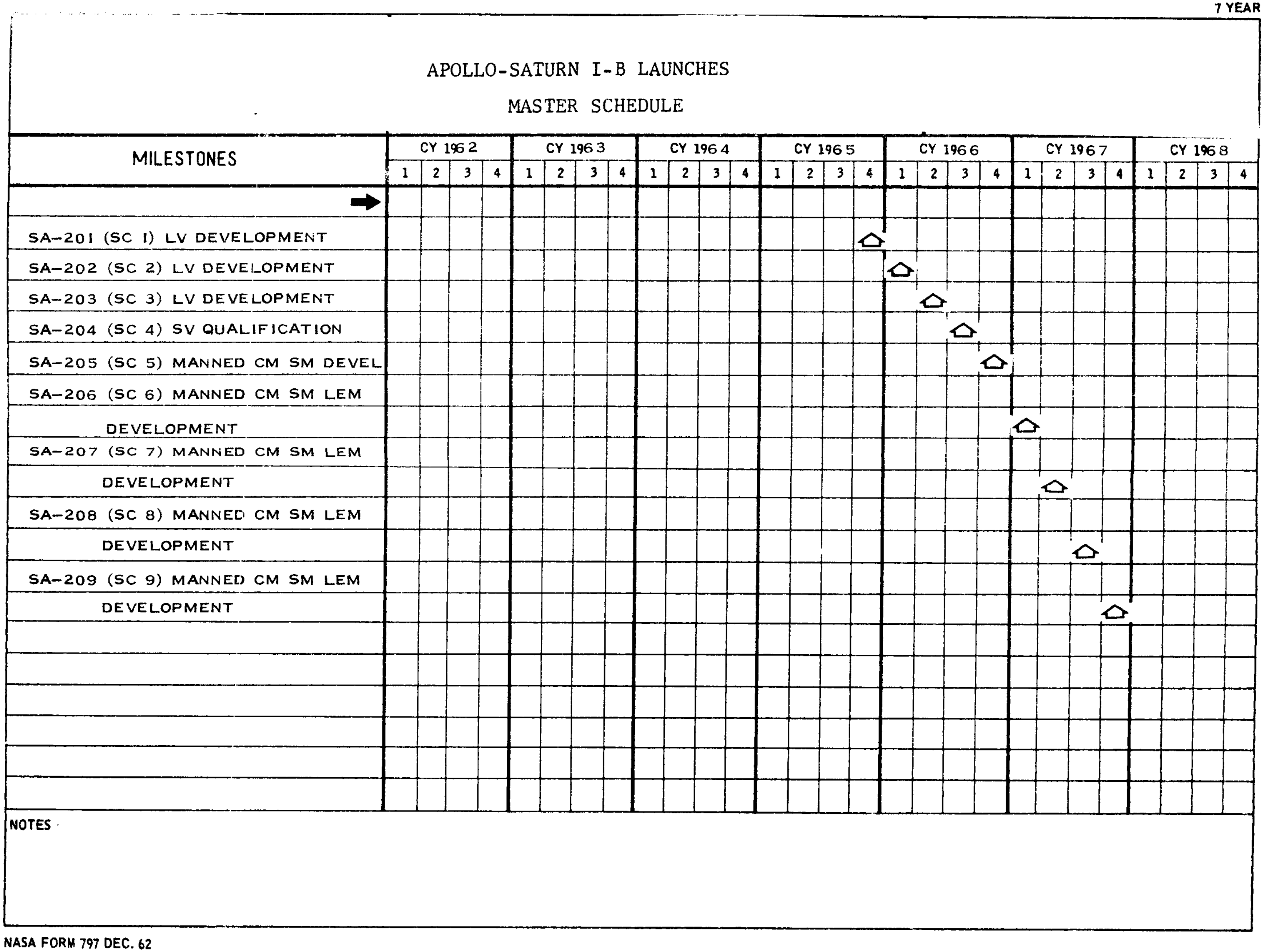

Figure 12.– Apollo Saturn I-B Launches (as of Sept. 30, 1963)

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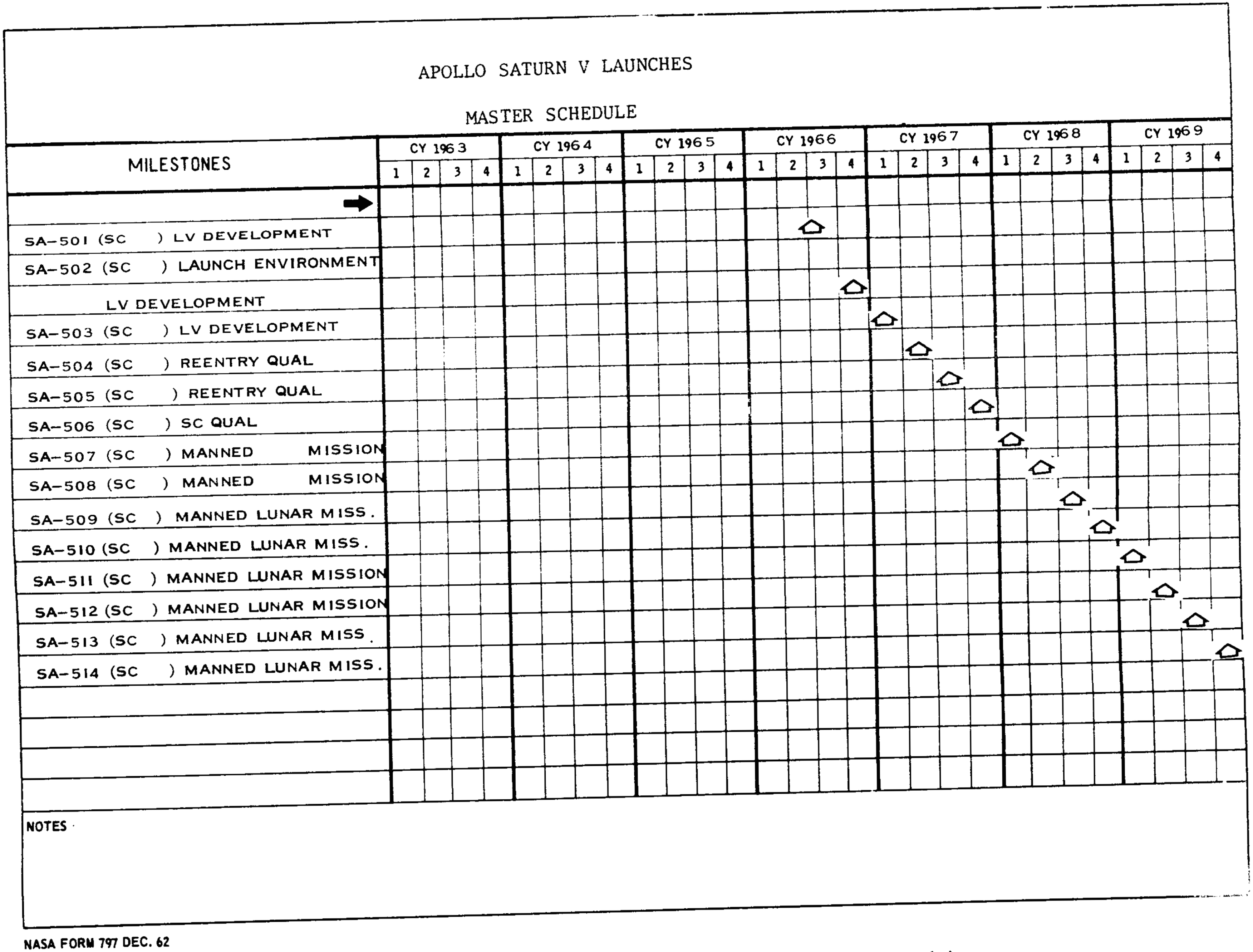

Figure 13.- Apollo Saturn V Launches (as of Sept. 30, 1963)